A COMPARATIVE STUDY OF VISUAL OUTCOME AND ASTIGMATISM CHANGES BETWEEN CONVENTIONAL AND SMALL INCISION MANUAL PHACO CATARACT SURGERY

THESIS FOR

MASTER OF SURGERY

(OPHTHALMOLOGY)

BUNDELKHAND UNIVERSITY
JHANSI (U.P.)

2004 **M. MANJUNATHA**

DEDICATED

TO

MY PARENTS

DEPARTMENT OF OPHTHALMOLOGY
M.L.B. MEDICAL COLLEGE, JHANSI.

CERTIFICATE

This is to certify that the work entitled ***"A comparative study of visual outcome and astigmatism changes between conventional and small incision manual phaco cataract surgery"*** which is being submitted as a thesis for M.S. (Ophthalmology) Examination, 2004 of Bundelkhand University, has been carried out by **Dr. M. Manjunatha** in the Department of Ophthalmology, M.L.B. Medical College, Jhansi.

The study has been conducted under my direct supervision and guidance. The observations recorded were periodically checked and verified by me.

This work fulfils the basic ordinances governing the submission of thesis laid down by Bundelkhand University.

He has put in the necessary stay in the department as per the University regulation.

Dated: 27/01/04.

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I wish to express my sincere gratitude to my patients whose co-operation is an essential part of any study.

With this I humbly submit this work as a step in the progress of cataract surgery.

Dated : / /

Dr. M. Manjunatha

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Introduction

Introduction

In India 81% of blindness is caused by ocular disorder cataract[1]. Cataract is the oldest ocular disorder known since the days of SUSRUTA. Cataract may be simply defined as "any opacity in the lens". Cataract (Greek word) the name comes from Latin word suffusio i.e. to rush down, as a waterfall, portcullis[2].

The treatment of choice for cataract is surgery. Earlier records of surgical therapy for cataract goes back to the days of SUSRUTA[3]. No surgical specialty has been so dominated by a single operation as ophthalmology by the cataract surgery. Cataract surgery has achieved its modern sophisticated status as a result of years of trials and errors with surgical maneuvers and technological innovation.

Increased patients awareness and recent progress in cataract surgery has heightened patients expectations about out comes of cataract surgery. Since, most of patients are desirous of the vision without spectacles, control of astigmatism is the key in meeting of patients expectations.

Improved microsurgical techniques currently enable the ophthalmic surgeons to maintain the emmetropic status of the patients postoperatively in most of the cases. However, inspite of these sophistication, significant postoperative corneal astigmatism can impair visual results in many patients.

DONDERS in 1864, was the first person to show the astigmatic changes after the cataract surgery[4]. Since then postoperative astigmatism was accepted as the natural

consequence of cataract surgery. The cataract surgical techniques have undergone a metamorphosis in terms of incision size, shape and site, suture material, techniques in order to achieve astigmatic neutrality in the postoperative period.

Now a days, cataract surgery is more of refractive rather then rehabilitative surgery. This give rise to new procedure called REFRACTIVE CATARACT SURGERY. The goal of this surgery is not merely to remove cataract but to allow the patient to see distant objects without glasses (spectacles).

With the establishment of planned large incision extracapsular cataract extraction, surgeons are on a lookout for methods to reduce the postoperative induced astigmatism. Several improvements were made in the incision and smaller incisions were tried. It was Dr. Richard Kratz (1983), who came up with the scleral tunnel incision[5].

Tremendous improvement in the cataract surgery has occurred in 1967, when Charles Kelman demonstrated phacoemulsification technique for cataract extraction in USA[6].

With the advent of new advanced and microsurgical techniques, phacoemulsification has become the preferred method for cataract extraction. But, because of its cost factor, sophistication and expertise required, therefore it is not available to all.

For delivery of high quality eye care to cataract patients, phacoemulsification is not absolutely necessary. Similar results were delivered by sutureless, selfsealing, small incision cataract surgery.

The conventional cataract surgery using a large clear corneoscleral incision was till date an ideal procedure. The advent of sutureless, selfsealing, small incision has posed a great

challenge to the conventional surgery because of the possible benefits regarding the postoperative induced astigmatism, visual outcome, early ambulation and patient comfort.

The present study is being taken to compare the postoperative visual outcome and induced astigmatism in patients undergoing extracapsular cataract extraction with posterior chamber lens implantation through sutureless, selfsealing manual small incision cataract surgery and conventional large incision extracapsular cataract extraction.

Aims and Objectives

Aim and Objectives

1. To study and compare the final unaided and aided visual acuity in conventional ECCE and small incision manual phaco cataract surgery.

2. To study and compare the postoperative induced astigmatism in conventional ECCE and small incision manual phaco cataract surgery.

3. Comparison of post operative astigmatism in small incision cataract surgery in the following subgroups:
   A. incision size - 6.5 mm vs. 8 mm.
   B. incision shape - frown vs. horizontal.
   C. incision site - superoscleral vs. temporal.

Review of Literature

Review of Literature

HISTORICAL REVIEW

The history of the evolution of the various surgical procedures for cataract removal is exhaustive.

The earliest records came from ancient Hindu writings, long before the Christian era. Operation of couching or reclination was widely employed in India in those days by SUSRUTA, a famous surgeon and has been continued until present century.

It is immense pleasure to say that we belong to the land of a great surgeon SUSRUTA, who introduced and practiced cataract surgery for the first time.

Duke Elder, in his book mentioned about this matter "it is interesting that while in Hindu medicine, cataract was defined by SUSRUTA as opacity due to derangement of the intraocular fluid, and subsequent history is full of fantasies and prejudices concerning its nature"[2].

In 1748, Jacques Daviel who made his own technique, thereby a revolution in ophthalmic surgery. He made incision in lower segment of cornea for removal of cataract lens[7].

In 1863, Julious Jacobson had practiced limbal section for cataract surgery for first time[8]. In 1866, Albreht Vongraffe introduced his technique "linear extraction" and introduced iridectomy in cataract surgery.

In 1867 Henry W Williams, first time introduced the corneoscleral suture and since then, many variations in the

application of sutures have been described in terms of technique and material[9].

The credit of development of intraocular lens implants and its utilization in cataract surgery goes to Harold Ridley (1951-1957). It made a revolutionary change in making patient emmetropia to a great extent[10]. IOL implants also undergoes sequential modifications like PMMA IOL, foldable IOL to accommodating IOL like multifocal or bifocal IOL. Extracapsular cataract extraction with posterior chamber IOL implantation has established itself as the best surgical modality of cataract surgery.

Early starting of the 20th century; ECCE was the treatment of choice for the cataract surgery, but development of cryo extraction, Vongraffe knife and specially designed anterior capsule spatula (arruga; duthie etc.) made ICCE more convenient than ECCE[11]. But development of IOL by Harold Ridley swung the surgical pendulum back towards extracapsular methods (ECCE).

Not only in the surgical techniques improved but physical advances in cataract surgery has occurred.

1. Surgical operating microscope with coaxial illumination has developed in order to provide the detailed observation and tissue differentiation.
2. Diamond and ultra short knives that allow minimizing the trauma of incisions.
3. Development of visco surgical substances (Healon) occurred during 1979, which made the cataract surgery less troubling by protecting endothelial damage during cataract surgery.
4. Development of phacoemulsification machine.

The concept of phacoemulsification commenced in 1948. In 1967, Charles Kelman in USA introduced phacoemulsification technique.

He showed the phacoemulsification of cataract lens and aspiration of lens material in a closed chamber. This stimulated great improvement in the extracapsular method of cataract extraction.

Milestones in the development of Small Incision Cataract Surgery (SICS)

After the development of phacoemulsification by Charles Kelman, there is tremendous improvement in the surgical techniques in order to provide the same result without using the phacoemulsification machine. To avoid the cost of surgery and long pain full learning course.

In 1983, Dr. Richard Kratz was the first surgeon to move the cataract incision site from limbus to sclera, thereby increasing the surface of opposed wound to produce enhanced wound healing and less astigmatism[5].

In 1984, Girand and Hoffman were the pioneers to call this posterior incision as "scleral tunnel incision"[12].

Jack A Singer in 1991, introduced the frown shape incision in small incision cataract surgery with less astigmatism postoperatively[13].

Paul H Earnest, introduced the concept of internal corneal lip (triplanar incision); acting as a one-way valve and imparting selfsealing property[14].

Professor Michael Blumenthal from Israel, developed his own technique in SICS for delivery of nucleus, known as the "Blumenthal mini nuc technique" and coined the term "epinucleus"[15-18].

There is development of modified Blumenthal techniques for the delivery of nucleus like phacofracture or phacofragmentation; sandwich technique or use of snare[19,20].

Milestones in the astigmatism

Thomas Young in 1801, was the first person to describe ocular astigmatism due to lenticular origin. Airy in 1827, showed the treatment of refractive error by using cylindrical lens.

In 1862, Knapp and Donders showed that astigmatism is due to corneal curvature changes.

In 1863, Donders was the first person to show the corneal astigmatism after cataract surgery.

In 1869, Snellen suggested that placing the incision on the steep axis would reduce the corneal astigmatism.

In 1991, Koch introduced the concept of "Astigmatic neutral funnel" for the control of surgically induced astigmatism in SICS[4].

HISTORY OF CATARACT SURGERY TECHNIQUES			
Year (AD)	**Technique**	**Place**	**Surgeon**
800	**Couching**	**India**	**Susruta**
1013	Needle aspiration	Iraq	Unknown
1100	Needle aspiration	Syria	Unknown
1500	Couching	Europe	Unknown
1745	ECCE inferior incision	France	Daviel
1753	ICCE by thumb expression	England	Sharp
1860	ECCE superior incision	Germany	Von Graefe
1880	**ICCE by muscle hook zonulolysis and lens tumble**	**India**	**Henry Smith**
1900	ICCE by capsule forceps	Germany	Verhoeff
1940	ICCE by capsule suction erysophake	Europe	Barraquer
1949	ECCE with posterior chamber IOL and operating microscope	England	Ridley
1951	Anterior chamber IOLs	Italy Germany	Strampelli Daneheim
1957	ICCE by enzyme zonulolysis	Spain	Barraquer
1961	ICCE by capsule cryoadhesion	Poland S. Africa	Krawicz, Amoils
1967	ECCE by phacoemulsification	U.S.	Kelman
1975	Iris – pupil supported IOLs	Netherlands	Binkhorst
1984	Foldable IOLs	U.S. S. Africa	Mazzocco Epstein
1991	Cataract refractive surgery	U.S.	Various
1993	Topical anesthesia	U.S.	Fischman
1997	Accommodating IOL prototypes	Europe	Cummings, Kamman
ECCE : Extracapsular Cataract Extraction , ICCE : Intra Capsular Cataract Extraction , IOL : Intra Ocular Lens			

REVIEW

Cataract Surgery has been as everlasting challenge against nature. Surgically induced astigmatism after cataract extraction is still a problem : despite variation in the type of incision, technique of suture and use of surgical keratometer and operating microscope.

In 1864, Donders was the first person to show the corneal curvature changes after cataract surgery. Afterwards surgically induced astigmatism (SIA) was considered as a natural consequence of cataract surgery.

Postoperative astigmatism following intraocular lens (IOL) implantation is largely corneal. Decay of astigmatism occurs rapidly in the first 6 weeks. This early decay of astigmatism is attributed largely to the

1. Resolution of wound oedema.
2. Dissipation of collagen contracture from scleral cautery.
3. Transient rise in intraocular pressure.

Many variables have been associated with astigmatism occurring in the cataract surgery. An individual factor is difficult to study in isolation because each operation requires a combination of events to achieve the goal of cataract removal, lens insertion and secure wound closure.

Intraoperative factors like incision, suture, cautery, intraocular lens (IOL) insertion are important cause for postoperative astigmatism.

Incision length related studies

Research data bears out the concept of less induced astigmatism with smaller incisions.

Armeniades & coworkers, studied the effect of incision length, location & shapes on the eye by finite element analysis & found that incision length was the most important of these factors[21].

Numerous studies demonstrated that smaller incision induce less initial with-the-rule (WTR) astigmatism & achieve stability faster than do larger incisions. There is gradual against-the-rule (ATR) astigmatic drift even with smaller incisions.

A 12 mm incision wound caused a profound structural disturbance of globe, whereas 3-5 mm scleral pocket incision wound produced no detectable radial tissue deformation.

Samuelson and associates studied induced astigmatism in cadaver eyes and found that there was a nearly linear increase in corneal flattening with increasing incision length. The maximal incision length that prevented flattening greater then 0.25 D was 3 mm[22].

Flaherty and Siepser, compared large incisions (10mm Limbal; 7mm scleral pocket) to smaller incisions (5mm Limbal ; 3-5 mm scleral pocket) in cadaver eyes and noted that the large incision group produced twice as much immediate postoperative astigmatism[23].

Hayashi K. Hayashi H et al (1995), studied 200 eyes undergoing sutureless cataract surgery who were randomly assigned into 3 groups according to the incision size. Group A 3.2 mm incision; group B 4 mm incision & group C 5 mm incision. All eyes were examined by corneal topography preoperatively as well as 2 weeks and 1, 3 and 6 months postoperatively. They found that the 3.2 mm incision hardly produced corneal shape change, whereas both 4 & 5 mm incisions produced small but persistent irregular steepening of the central cornea[24].

Investigators	N	Technique	Incision size (mm)	Mean SIA 1 week (in Diopters)	Mean SIA 4 week (in Diopters)
SIA after Small Incision Surgery (4 mm or less)					
Davison	130	Phaco	4	0.8	0.49
Gills , Sanders	55	Phaco	3	NA	1.07
Leen et al	26	Phaco	4	2.78	1.33
Martin et al	55	Phaco	3.5 – 4	1.17	NA
Neumann et al	67	Phaco	3 – 4	NA	1.29
Oshika	52	Phaco	3.2	0.69	0.58
Pfieger	56	Phaco	3.5	0.75	0.73
Rainer et al	63	Phaco	4	0.85	0.60
Shepherd	99	Phaco	4	0.13	0.02
Steinert et al	65	Phaco	4	1.54	0.98
Uusitalo et al	10	Phaco	4	0.02	0.05
SIA with incision length (5 – 7 mm)					
Davison	146	Phaco	5.5	0.69	0.41
Gills , Sanders	48	Phaco	6 – 7	NA	2.27
Leen et al	30	Phaco	6	2.4	2.28
Martin et al	56	Phaco	6	2.26	NA
Neumann et al	56	Phaco	6	NA	1.06
Oshika	46	Phaco	6.5	0.93	0.66
Steinert et al	65	Phaco	6 – 6.5	3.07	1.44
Werblin	102	Phaco	6.5	NA	1
SIA with incision length (more than 7 mm)					
Leen et al	31	ECCE	11	2.47	2.58
Neumann et al	59	ECCE	10	NA	2.27
Oshika	26	ECCE	11	2.83	1.32
Uusitalo et al	10	Phaco	7.5	1.51	0.19
Werblin	36	ECCE	12	NA	1.9

Abbreviations : N = Number of eyes, Tech = Surgical technique, SIA = Surgically induced astigmatism, Phaco = Phacoemulsification, ECCE = Extra Capsular Cataract Extraction.

Holwegar RP and Marefat B (1997), studied the corneal changes after phacoemulsification cataract extraction with lens implantation with 3.5 mm clear corneal sutureless incision and 5 mm clear corneal incision with single absorbable sutures in 200 eyes, which were randomly distributed into 2 groups. Corneal topography and endothelial cell count was performed both

preoperatively and postoperatively at 6 & 8 months. They found that all closures produced only minimal changes in corneal topography indices[25].

El Meghraby A et al (1993), studied 151 patients undergoing cataract surgery and intraocular lens implantation. They randomly divided the patients into 3 groups. Group A, receiving silicon IOL through 3.5 mm incision. Group B receiving loptex IOL through 5.5 mm incision & group C receiving PMMA IOL through 6.5 mm incision. They found that one week postoperatively 62% of 3.5 mm incision cases had uncorrected visual acuity 20/40 or better compared to 33% in 5.5 mm group and 43% in 6.5 mm incision group. After 2 months 85% of 3.5 mm incision group had 20 / 40 visual acuity or better as compared to 64% of 6.5 mm incision group and 71% of 5.5 mm incision group[26].

Levi JH, Pisacono et al (1994), evaluated postoperative astigmatism in 80 eyes by keratometry that had phacoemulsification and intraocular lens implantation through sutureless corneal incisions. They found that early postoperative astigmatism (1 - 3 months) vector analysis showed less induced astigmatism in the 3.5 mm group than in the 5.1 mm group. Uncorrected visual acuity during the postoperative period was also better in the smaller incision group[27].

Muller Jensen K, Zimmerman H (1996), studied the astigmatism in 211 patients who had cataract extraction and intraocular lens implantation through a superior clear corneal incision; 108 patients had phacoemulsification with 4 mm no stitch surgery & 103 had ECCE using 12.0 mm sutured corneal incision. The main outcome measured was amount of astigmatism preoperatively, after 1 week and 3-6 months postoperatively.

Median surgically induced cylinder was 1.0 Diopters in 4 mm no stitch surgery and 1.75 Diopters in 12.0 mm sutured incision group[28].

Location related studies

Based on keratorefractive principle; more peripheral & shorter cataract incision should induce less astigmatic change.

Thrasher & Boerner, compared anterior incision location (1 - 1.5 mm from limbus) to posterior incision location (2.5 mm from limbus) for both phacoemulsification & ECCE (9.5 mm incision) in 103 cases & found significant change 6 weeks postoperatively from the preoperative astigmatism in both of the anterior groups but not in the posterior group[29].

Anderson & colleagues, found no significant differences after the first postoperative day between groups with a 7 mm superior incision placed either 1 mm behind the limbus or 1 mm infront[30].

Difference in incision depth (300 µm & 500 µm) had no effect on postoperative astigmatism.

Andermatter R et al (1991), studied 639 cases undergoing cataract extraction. The patients were randomly assigned into 2 groups. Groups A, 391 patients in whom the location of incision was corneal and Group B, 248 patients in whom the location of incision was limbal. They found that corneal incisions gave significantly more against-the-rule (ATR) astigmatism (mean 0.61 Diopters) than limbal incision (mean 0.32 D). They also found that suture induced astigmatism has no determining effect on the final astigmatism. All patients underwent extracapsular cataract extraction with sutured incision[31].

Korynta J (1998), evaluated the results of keratometry in 235 patients after posterior limbal & scleral tunnel incision. Posterior limbal section induced +4D of astigmatism on average as compared to +2D in scleral tunnel incision slight astigmatism persisted is the posterior limbal incision after 4 months while it disappeared in scleral tunnel incision[32].

Zheng H et al (1997), studied the induced astigmatism change using vector analysis. The change in induced astigmatism was studied for 8 yrs after large incisions ECCE in 144 eyes, for 3 yrs after 6mm division in 93 eyes, for 2 years after 3mm, superior incision in 120 eyes and for 18 months after 3mm superior incision in 120 eyes and for 18 months after 3mm temporal incision in 65 eyes. The last 3 groups underwent phacoemulsification. They found that induced astigmatism 2 weeks postoperatively in the first groups was + 3.47D which decayed to – 1.25D after 6 months and increased gradually to – 1.67D after 8 yrs. In the latter 3 groups the induced astigmatism on the first postoperative day + 1.23D, + 0.49D, +0.19D astigmatism on the first postoperative day + 0.49D, + 0.19D respectively. In the 6mm incision group the astigmatism stabilized in 3 months. In the 3mm superior incision group astigmatism stabilized in 6 weeks & at 18months it was 0.35 D while in the 3mm temporal incision no significant change in the astigmatism was detected at any time[33].

Comparative studies by Korynta, Muller et al and Zhen et al showed that 12mm conventional surgery is associated with higher astigmatism in the range of 2-4D as compared to sutureless surgery having astigmatism in the range of 1-2 D.

Syn KA, Kropinska E (1998), in their study to compare postoperative astigmatism in corneoscleral incision & sutureless

surgery concluded that higher induced astigmatism was seen in corneoscleral incision while there was low astigmatism with prompt stabilization in small incision sutureless surgery[35].

The effect of incision placement in other then the superior meridians has received attention.

Masket noted that against-the-rule (ATR) astigmatism was reduced by a temporal incision for secondary insertion of an intraocular lens (IOL) in aphakic patients[34].

Cravy observed that a lateral approach for extracapsular cataract extraction (8.5 to 9.5mm) produced significantly less astigmatism then the identical surgery situated superiorly[36].

Anders & colleagues noted significantly more astigmatism 8 months postoperatively with superior scleral & limbal incision than with temporal scleral & limbal incision.

Kawano compared 6mm corneoscleral incision placed either superiorly or between 9 O'clock & 12 O'clock [BENT incision] and found significantly less induced astigmatism and more rapid stabilization in the horizontal incision[37].

Placing BENT (bet 9 & 12 O'clock) incision directly on the steep axis of patients with oblique astigmatism has been effective in reducing astigmatism.

Oshima and associates found no significant difference in mean surgically induced cylinder between 40 eyes 3 mm superoscleral tunnel incision & 40 eyes with 3 mm temporal clear corneal incisions. Although the standard derivations are larger in the corneal incision group [38].

Junsuke Akura, Shuzo Keneda, Shiro Hatta, Kazuki Matsuura, in their study they concluded that, the bent frown incision effectively achieves astigmatic neutrality and the incisions on the

temporal or superior steep astigmatic axis (with selective shape) reduced astigmatism in almost all cases, using modified large selfsealing 6 – 7 mm incision[39].

Investigators	N	LOC	Incision size (mm)	Mean SIA 1 week (in Diopters)	Mean SIA 4 week (in Diopters)
Scleral tunnel incisions					
Anders et al	NA	ST/S 1 mm	7	0.69	0.93
	NA	ST/T 1 mm	7	0.70	0.7
Gross, Miller	93	ST/S 2.5 mm	4	1.26	1.05
Oshima et al	40	ST/S 2 mm	3	0.76	0.65
Singer	34	ST/S 2 mm	7	1.19	1.07
Wirblauer et al	18	ST/S 2 mm	7	1.86	1.76
	15	ST/T 2 mm	7	1.49	1.53
	22	ST/O 2 mm	7	1.33	1.13
Clear corneal incisions					
Gross, Miller	105	CC / T	3.2 – 3.5	0.76	0.749
Kmrnamm, Dornbach,	130	CC / O	3 – 4.5	1.2	1.21
	65	CC / T	3 – 4.5	0.85	0.75
Long, Monica	98	CC / T	3 – 3.5	0.96	0.73
	35	CC / S	3 – 3.5	1.17	1.14
Masket, Tennen	45	CC / T	3	0.46	0.52
Mueller, Jensen	50	CC / S	4	1.67	1.12
Barlinn	50	CC / T	4	0.89	0.05
Niolson	17	CC / S	3.5	0.93	0.56
	16	CC / T	3.5	0.55	0.59
	10	CC / S	5.2	1.44	1.47
	11	CC / T	5.2	1.41	1.2
Oshima et al	40	CC / T	3	0.86	0.5
Pfleger et al	35	CC / T	3	0.65	0.71
	31	CC / T	5.2	1.27	0.95

Abbreviations : N = Number of eyes, LOC = Incision location, SIA = Surgically induced astigmatism, ST/S = Superoscleral tunnel , ST/T = Temporal scleral tunnel, ST/O = Oblique scleral tunnel, CC/T = Temporal clear cornea, CC/S = Superior clear cornea.

Incision shape related studies

Singer JA (1991), compared the postoperative astigmatism in 62 patients undergoing phacoemulsification with lens implantation

through 6 or 7 mm frown incision shape scleral tunnel and 34 patients undergoing the same procedure with standard straight incision shape scleral pocket. The induced astigmatism for the frown incision versus straight incision was 0.8 D to 1.19 D at one day, 0.74D to 1.03D at one week 0.84D to 1.15D at 6 months respectively[40].

SUTURE

Next to the incision suture is the main determinator of the astigmatism.

Suture related causes like

1. Type of material used.
2. Technique of suturing.
3. Tightness of suturing.
4. Suture removal.

(1). Suture material related studies:

Pearce (1970), compared postoperative astigmatism with the use of different suture materials, indicating that there is a reduction in the astigmatism from 1.72 Diopters with virgin silk to 0.9 Diopters with monofilament nylon[41].

Dekkers and Buijs (1989), divided 206 consecutive cataract patients at random into three groups according to the way the cataract incision was closed. Virgin silk 8 – 0, interrupted nylon 9 – 0, double running nylon 9 – 0. The nylon, whether interrupted or continuous, yielded in the majority of cases a postoperative astigmatism with-the-rule (WTR), whereas virgin silk caused in nearly all patients a postoperative astigmatism against-the-rule

(ATR) and therefore behaved like an absorbable suture[42]. Silk is chemically non-absorbable, but in virgin silk a natural worm produced polymer is still present, which provokes a tissue reaction. Softening of tissue diminishes the tensile strength of the suture, with respect to the postoperative astigmatism, the suture material (nylon or virgin silk) seems a more important factor than the way in which it is used (interrupted or continuous).

Initially with-the-rule (WTR) astigmatism has been attributed to wound compression from tight sutures, wound oedema, cautery and increased intraocular pressure after surgery. Resolution of wound oedema, cheese wiring of tissue by the suture material and loss of suture tensile strength may contribute to the suture decay. The tempo of suture decay is partially dependent on the suture material used.

Jaffe and Claymann (1975), noted with-the-rule (WTR) astigmatism 5 – 7 weeks postoperatively in patients whose incision was closed with monofilament nylon, as compared with against-the-rule (ATR) astigmatism in patients whose incision was closed with absorbable catgut sutures[43].

(2). Suture technique related studies:

Various authors have noted the initial inducement of with-the-rule (WTR) astigmatism after interrupted or continuous suture, closure of intracapsular or extracapsular surgery, followed by a decay in cylinder magnitude and a shift in cylinder axis towards against-the-rule (cylinder regression).

Luntz and Livingston, reported with-the-rule astigmatism ranging from 1 – 10.5 Diopters after continuous closure with 10 – 0 nylon dependent on suture tightness[44].

Thygesen, Reested, Fledelius and Corydon (1979), followed a corneal astigmatism after cataract surgery followed by a way of corneal incision (C,n = 62) and corneoscleral incision (CS,n = 61). Corneal incisions were closed by continuous nylon 10 – 0, corneoscleral incision was sutured with single knots. Keratometric results in the C and CS groups were compared concerning the degree of astigmatism, preoperative median values were 0.5 and 0.7 Diopters respectively. After one week they were 4.5 and 3.0 Diopters, after two weeks 3.3 and 3 Diopters, after 4 months 3.0 and 2.0 Diopters, after 6 months (final status) 1.5 and 1.7 Diopters respectively. The differences between C and CS are significant, for both, astigmatism after cataract surgery did not quite return to preoperative levels. Concerning the axis (weaker meridian) of corneal astigmatism, the C cases retained their preoperative distribution, while the CS cases showed the classical shift towards the against-the-rule (ATR) astigmatism. Final corrected visual acuity was of the same order in the C and CS group[45].

Meredith and Maumenee (1979), in a review of 1000 cases of intracapsular cataract extraction found that the total amount of astigmatism produced by all the suturing techniques was similar, with interrupted suturing techniques, the axis of the correcting cylinder was more against-the-rule, while continuous closures with monofilament nylon more frequently produced with-the-rule astigmatism[46].

Stainer, Binder, Parker and Perl (1982), performed sequential central keratometry on 52 cataract patients for six months, they found no statistically significant difference in the induced postoperative astigmatism between wound closure with interrupted and double shoe lace running closure with 10 – 0 monofilament

nylon. In 31 patients, the postoperative astigmatism was always with-the-rule. In 21 patients who underwent wound closure with 8–0 polyglactin suture, they documented a postoperative shift in induced astigmatism from with-the-rule (WTR) to against-the-rule (ATR), which took place between the 4th and 5th postoperative week[47].

Ivekovic, Manoic, Mamndic and Skegro (1994), analyzed the occurrence and changes of postoperative astigmatism in three groups of patients after they performed extracapsular cataract extraction, regarding the type of the applied sutures, single, continuous double row and combined suture. 150 eyes were followed up for over the period of 6 months. The quickest decreasing of astigmatism and its lowest values were recorded in the application of the combined suture. A statistically significant decrease of astigmatism values ($p < 0.01$) was already found after one month, and after 6 months 98.7% of the operated eyes had postoperative astigmatism lower than 0.9 Diopters[48].

Bellucci et al (1996), evaluated corneal topography and astigmatism after cataract surgery with 8 mm scleral tunnel incision closed with a continuous 10 – 0 nylon suture in 20 eyes. Corneal topography (Eye sys 2.1) was evaluated for the first 5 months. Astigmatism (absolute and induced) was measured by Javal ophthalmometry preoperatively and 1, 7, 30, 60, 90, 150 and 360 days after surgery. In the week following surgery, corneal shape was minimally affected and uncorrected visual acuity was not compromised. Mean with-the-rule induced cylinder was less than 1 Diopter. After 5 and 12 months, the mean induced cylinder was still less than 1.5 Diopters but with an against-the-rule shift in almost all eyes. They concluded that, the sutured 8 mm tunnel incision

showed good results in terms of absolute cylinder but late against-the-rule shift could not be avoided[49].

Skubiszewska et al (1996), examined the astigmatism in 107 eyes of 92 patients who underwent cataract extraction mostly with IOL implantation. In 52 cases, phacoemulsification with tunnel incision, measuring 5 mm in 27 and 8 mm in 25 cases was performed. In the control group of 55 eyes , incision with scleral flap measured 2 / 5 of the corneal circumference. In cases with 5 mm incision, no suture were used, in 8 mm incision wound were closed with single suture and in control group the double continuous suture was applied. Astigmatism was measured in 2 days, 1 week, 4 week, 3 months after surgery. They found that, the postoperative astigmatism decreased gradually and after 3 months was average 0.14 Diopter in the eyes without sutures, 0.68 Diopters in those with single ones and 1.78 Diopters in the control group[50].

(3).Suture cutting:

Selective cutting or removal of interrupted sutures in the axis of steepest curvature has proven utility in reducing postoperative with-the-rule astigmatism. A single tight suture is recognized by the axis of plus cylinder and the axis of higher keratometric measurements.

Talamo and associates recommended selective suture cutting at 8 – 10 weeks if more than 3 Diopter of with-the-rule astigmatism was present, 3 – 5 weeks after the surgery, unless there was significant pre-existing with-the-rule astigmatism[55].

Richards and colleagues, cut sutures between 4 and 7 weeks without any wound leaks or dehiscence. Comparisons between groups with sutures cut and not cut showed a significant difference

in corneal curvature after upto 1 year, but no difference at 3 – 4 years[56].

Kronish and Forster, cut sutures 6 weeks after surgery, after discontinuation of topical steroids, without complications. They removed from1 – 3 sutures, depending on the amount of cylinder present, cutting none for upto 2 Diopter with-the-rule astigmatism, each suture cut reduced postoperative cylinder by 1.2 Diopters. At 1 year, there was no significant difference in the amount of astigmatism among groups with none, one, two or three sutures cut[57].

Luntz and Livingston (1977), reported their investigation into astigmatism in 40 eyes following a corneal cataract incision closed with continuous 10 – 0 nylon monofilament suture. Immediately after surgery, suture induced astigmatism was vary, its severity depending on the tightness of the sutures. It ranges from 1 – 10.5 Diopter, the mean value 4.09 Diopter with a standard deviation of ± 2.5 Diopters[63].

Removing the nylon suture eliminated this astigmatism and within a few weeks the corneal astigmatism correction in 48% of eyes returned to the preoperative level. In 80% of eyes the difference between the final postoperative corneal astigmatism (4 months after removing the continuous suture), and the preoperative astigmatism was 0.75 Diopters or less, and the maximum change was 1.5 Diopters. In 40% of eyes the axis of the cylinder changed from a horizontal to an oblique axis, but did not change from with-the-rule to against-the-rule. The degree of astigmatism remained constant, while the suture was in place and in 50% of eyes it was equal to or less than 3 Diopters. The degree of astigmatism following the corneal section and continuous nylon suture

compares favorably with astigmatism, following suturing techniques for cataract.

Stanford, Fenech and Hunter (1993), carried out a prospective, randomized study in 135 patients, to determine whether the time of removal of continuous sutures in the relief of postoperative astigmatism had any affect on subsequent changes in cylinder power or axis. After uncomplicated extracapsular cataract extraction with a corneal section and continuous 10 – 0 nylon sutures, patients with more than 3 Diopters of cylinder were allocated to have their suture removal at 6, 9 or 12 weeks postoperatively. Visual and optical outcome was accessed 1 week after suture removal and at 6 months. Although the time of removal did not affect the change in cylinder power, the subsequent reflection was more stable when the suture was removed at 12 weeks. However, initially against-the-rule astigmatism did not significantly change after suture removal and resulted in an unsatisfactory final prescription. Suture removal should therefore be performed at 12 weeks, glasses should not be prescribed early, and a poor outcome may be anticipated in those initially against-the-rule astigmatism[51].

Pont Chova E, Cernak A, Siskova E and Potocky M (1995), compared corneal astigmatism before cataract surgery and the late postoperative corneal astigmatism (minimum 8 months after surgery) ECCE was done with IOL implantation, with a limbal approach and the wound was sutured with 5 – 6 single interrupted sutures. Two months after surgery all sutures were removed in astigmatism with-the-rule higher than 3 Diopters. The average value of the corneal astigmatism with-the-rule before surgery was 0.42 ± 1.19 Diopters, and late postoperative astigmatism against-

the-rule was 0.19 ± 1.18 Diopters. Forty three eyes (69.4%) had the difference between preoperative and late postoperative corneal astigmatism less than 1.5 Diopters. 19 eyes (30.6%) had the difference higher than 1.5 Diopters, 12 eyes (19.5%) had the postoperative corneal astigmatism against-the-rule higher than 1.5 Diopters. They found positive correlation between preoperative and postoperative corneal astigmatism ($0.001 < p < 0.001$)[52].

Krishnamachary and Basti (1997), in a prospective, randomized study evaluated the effect on astigmatism of two techniques of suture release in 30 patients, with more than 3 Diopters of corneal astigmatism, after cataract surgery. All patients had interrupted sutures with healed wounds. 15 patients had all suture release (ASR), irrespective of the location of the steep meridian. In the other 15, only the suture located in the steep meridian was selectively released (SSR). The pattern of decay of astigmatism after suture release was studied using computerized video keratography. Mean pre-treatment corneal cylinder was 6.30 Diopter ± 2.7 (SD) in the ASR groups and 6.95 ± 1.67 Diopters in the selective suture removal (SSR) group. In the ASR group, corneal cylinder dropped to 3.70 ± 1.15 Diopters, immediately after suture release, and further decreased to 1.82 ± 0.66 Diopters at one week ($p < 0.001$). In the SSR group, astigmatism swung erratically to the adjoining sutures and decreased unpredictably at an average of 1.32 ± 2 Diopters with each suture released. They concluded that the ASR technique was more predictable and less cumbersome than the SSR method[53].

With or without suture, for incision closure related studies

Groenholm in 1935, evaluated 200 cataract surgeries with keratometry and found that 10 days postoperatively the average astigmatism was 8.9 Diopters against-the-rule in those without sutures and 4.8 Diopters against-the-rule in those with two corneoscleral sutures.

Floyd reported in 1951, that postoperative with-the-rule astigmatism is a suture phenomenon because it is not seen in unsutured cases and disappears on removal of corneoscleral sutures[54].

Smyk, Kropinska E, Orzalkiewic ZA et al (1998), evaluated induced astigmatism in 94 eyes after cataract extraction with IOL implantation, 7 days, 1 month, 3 months, 6 months and 12 months after operation two groups were compared[35].

Group 1 - After extracapsular cataract extraction with corneoscleral incision (10 – 2 O'clock) and continuous cross like suture.

Group 2 - After phacoemulsification with sclerocorneal tunnel incision (3.3 mm) without suture.

The highest induced astigmatism was observed 7 days after surgery in patients with longest corneoscleral incision with suture (group 1). Induced astigmatism gradually decreased in time. In group 2 after phacoemulsification especially with no suture, low astigmatism with prompt stabilization was observed. They concluded that the length and type of closure of the incision have an essential effect on the induced astigmatism. Small incision, especially without suture induces minimal early postoperative astigmatism, which remains stable.

IOL insertion and postoperative astigmatism related studies

New questions arise with increased use of intraocular lenses. Astigmatism, although primarily corneal in origin, may be produced when any element, including the fovea is not centered along the effective optic axis of the eye.

Cataract surgeons noted higher levels of cylinder in patients with IOLs than in those with spectacle corrected aphakia. Binkhorst attributed this to the optical principle of effectivity. Aphakic or high plus spectacles are generally fabricated in plus cylinder, which reduces the cylinder power 25 – 35% relative to the astigmatism in the corneal plane, whereas spectacles in the normal power range are fabricated with minus cylinder, effectively increasing the cylinder power relative to the cornea[65].

Moore (1980), compared 100 intraocular lens implantation cases with 328 non-implant cases and found that postoperative astigmatism was proportionately far higher in the implant cases[66].

The factor cited to explain this result were as follows:-

1. Irregular corneal healing.
2. Tilt of intraocular lens (IOL).
3. Optical aberrations of the intraocular lens (IOL).
4. Weight of the lens pulling on or disturbing other intraocular structures.

Sivak and associates, in a study of IOLs from several manufacturers, found no design, material or fabrication flaws and concluded that IOLs are not a common source of astigmatism[67],

Jolson and Seidl, reported a case of lens tilt with 4 Diopters of cylinder caused by fibrous proliferation, which resolved with Nd : YAG laser release of the fibrous band and reduction of the tilt[68].

Significant tilting is required to induce clinically significant cylinder. A 20 Diopter IOL must be inclined 10^0 from the vertical plane to cause 1 Diopter of cylinder.

(4). Cautery related studies:

Bregmann and associates in a study of cadaver eyes, found significant mean vertical with-the-rule (WTR) steepening of the cornea, after cauterization of 5.5 mm and 11 mm chord length incisions[69]. This was attributed local flattening from shrinkage of collagen, similar to suture compression. Loss of this effect through wound remodeling may account for decrease in with-the-rule astigmatism of superior wound seen in the first postoperative week.

(5). Wound healing related studies:

The gradual against-the-rule astigmatic changes were associated with the superior incision may be secondary to ongoing wound changes. Factors such as the general health, nutritional status and topical steroids use may affect ocular wound repair.

Stainer and coworkers found that intracapsular cataract patients whose incisions were closed with polyglactin sutures and who received topical 1% prednisolone acetate four times a day for more than four weeks experienced a significant increase in ATR astigmatism 4 to 10 weeks postoperatively, compared with similar patients on the same topical steroid regimen for less than 2 weeks[70].

MECHANISM OF POST OPERATIVE ASTIGMATISM IN CATARACT SURGERY

Many variables have been associated with astigmatism occuring in the setting of cataract surgery. An individual factor is difficult to study in isolation because each operation requires a combination of cataract removal, lens insertion and secure wound closure.

The factors affecting postoperative astigmatism are :

A. Preoperative
1. Native astigmatism
2. Corneal changes
   - undetected keratoconous
   - Corneal scarring
3. Scleral changes
   - Thinning, surgery i.e. Buckle

B. Intraoperative
1. Incision :
a. Extent [size]
b. Location [site]
c. Type [shape]
2. Wound Closure :
a. Suture material
b. Suture technique
c. Suture configuration
d. Number of sutures
e. Depth of sutures
f. Width of sutures
g. Tightness of sutures
3. Sutureless Cataract Surgery:
4. Healing Process:

C. Postoperative
1. Wound healing, nutrition, topical steroids
2. Suture slippage or cutting
3. IOP

1. Incision:

In cataract operation, the placement of incision is the most vital step in the performance of operation. A bad incision can effect not only the whole procedure, but also its postoperative course. A perfect incision makes a frame work for a perfect cataract extraction as well as the closure of the incision after operation. Incision can be studied in the following headings:

1. Incision Size
2. Incision Shape
3. Incision Site

1. **Incision Size**: (Figure 1)

The chord length of different types of cataract extraction is as follows:

	ICCE	ECCE	SICS	Phaco
Incision size	10 – 12 mm 3 – 9 O'clock	8 – 10 mm 2–10 O'clock	< 8 mm	3 – 4 mm
Astigmatism	+++	++	+ / -	-

Choosing the proper wound extent involves a compromise. A long incision makes the extraction easy but it increases both the chances of inducing significant astigmatism and also the problems related to wound size, such as hyphaema, wound leak etc. Smaller incision associated with fewer postoperative wound complication and less astigmatism.

The length of incision may vary between 8 – 12 mm in case of conventional ECCE and 5 – 7 mm in case of manual small incision cataract surgery. The incision size depends upon the size and density of the nucleus and optic of the IOL (non foldable IOL).

2. **Location of Incision** (Figure 2)

Postoperative astigmatism can be reduced by varying the location of incision.

FIGURE 1. INCISION SIZE.

Extent of incision varies with location. A 90-degree incision made at anterior limbal border, *A-A'*, will have amplitude of 10 mm, *D*, and will just barely permit passage of lens. A 90-degree corneal incision, *C-C'*, will have smaller amplitude, whereas midlimbal, *M-M'*, and posterior limbal, *P-P'*, incisions have larger amplitudes. Posterior limbal incision has amplitude of 13 mm, *E*.

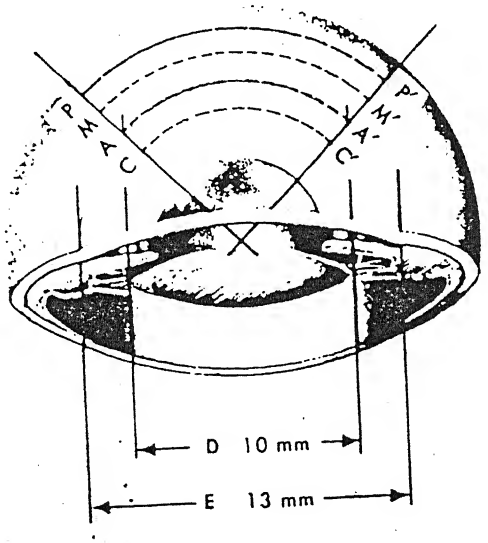
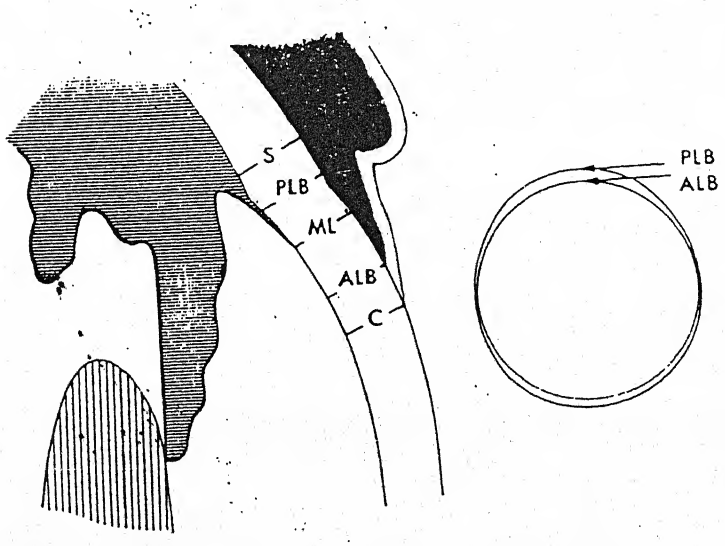


FIGURE 2. LOCATION OF INCISION.



Variety of locations of cataract incisions. *C*, Corneal; *ALB*, anterior limbal border; *ML*, midlimbal; *PLB*, posterior limbal border; *S*, scleral.

Influence of incision site on surgery

	Corneal	Limbal	Scleral
Postoperative astigmatism	+++	++	+
Bleeding	-	+	++

The various locations of incision are corneal, anterior limbal border, mid-limbal, posterior limbal border and scleral.

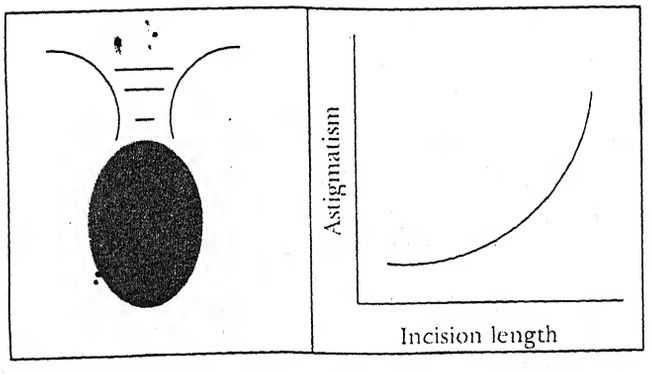
In ECCE (conventional), usually done at mid-limbal site, whereas small incision cataract surgery (manual phaco) usually done in the scleral area. In the sclera, 3 sites for placing of incision

a. Superoscleral.
b. BENT (between 9 and 12 O'clock).
   (Superotemporal site for right eye.)
   (Superonasal for left eye.)
c. Temporal

A. Superoscleral (Figure 3): In 1991, Koch introduced the concept of incisional funnel to integrate both incision length and location as factors in postoperative wound gape and astigmatism[60].

The incision funnel incorporates both the linear relationship between the cube of the incision length and astigmatism, and the inverse relationship between astigmatism and the distance between the incision and the limbus, to define a space within which incision

FIGURE 3. KOCH'S INCISIONAL FUNNEL.



should be astigmatically neutral. Incision placed in the funnel, regardless of length, have equivalent degrees of stability.

$$\text{Astigmatism} \propto \frac{(\text{Incision length})^3}{\text{Distance from limbus}}$$

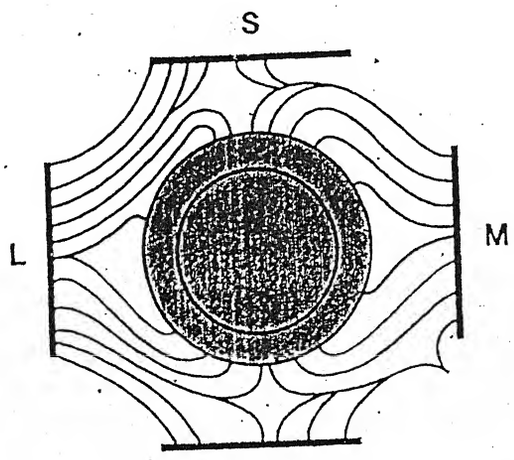
An easy way to determine the site of commencement of the scleral incision as follows:

Site of Incision = Planned horizontal width – 2
(from posterior extent of limbal gray zone)

For example :
1.) 3 mm foldable silicon IOL, the site would be 3 – 2 = 1 mm from posterior to the limbal gray zone.
2.) Similarly for a 6 mm IOL it would be 6 – 2 = 4 mm from posterior to the limbal gray zone.

B. BENT site: (Figure 4) Junsuke Akura worked more on the BENT incision site in SICS. Placing BENT (between 9 and 12 O' clock) incision directly on the steep axis of patients with oblique astigmatism has been effective in reducing astigmatism, because the external part of the BENT frown incision follows the direction of the scleral fibres, whereas the superior and temporal incision cuts the scleral fibres vertically.

FIGURE 4. DIRECTIONAL ARRANGEMENT OF SCLERAL FIBRES.



C. Temporal site: Placement of incision in the temporal site have much more advantages compared to the superoscleral and BENT site, because

1. It is less influenced from the eyelids.
2. It is less influenced from the extraocular muscles.
3. It is slightly away from the visual optic axis.
4. Temporal vertical incision re-epithelize quickly than the superior horizontal incision.

Jaffe (1972) supported by Paton (1973), quite firmly considers that a corneal or anteriorly placed incision induces astigmatism against the rule. Jaffe has reached the following conclusions :

(a) Anterior incisions (incisions close to the center of the cornea) cause greater flatting of the vertical meridian of the cornea than do posterior incisions. Thus a corneal incision is likely to cause more astigmatism against the rule than a scleral incision.

(b) Incision that end at or beyond the horizontal meridian tend to neutralize some of the flattening of the vertical meridian. Thus if the incision is scleral at 12 O' clock and limbal or corneal at 3 and 9 O' clock, there may be more flattening of the horizontal meridian which results in astigmatism with the rule.

(c) The smaller the amplitude of the incision above, the less the effect on the horizontal meridian. If such a incision is corneal or anterior limbal, it will result in greater flattening of the vertical meridian (against the rule astigmatism) than a more scleral incision.

(d) Separation of the wound (by filtering bleb) has little effect on the amount of postoperative astigmatism when the incision is scleral, but causes considerable astigmatism when the incision is more anterior.

Thus postoperative astigmatism is less in corneoscleral incision and relatively more in corneal incision. The postoperative astigmatism can be prevented in eyes with no pre operative corneal astigmatism by a relatively short scleral incision to avoid flattening of either meridian. Also the pre existing corneal astigmatism can be reduced by using a specific location and extent of the corneoscleral section.

3. **Incision Shape (Configuration)** (Figure 5)

The cataract incision may proceed from the outer surface of the globe to the anterior chamber in several planes such as

1. Perpendicular
2. Beveled
3. Combined (perpendicular and beveled)
4. Three plane etc.

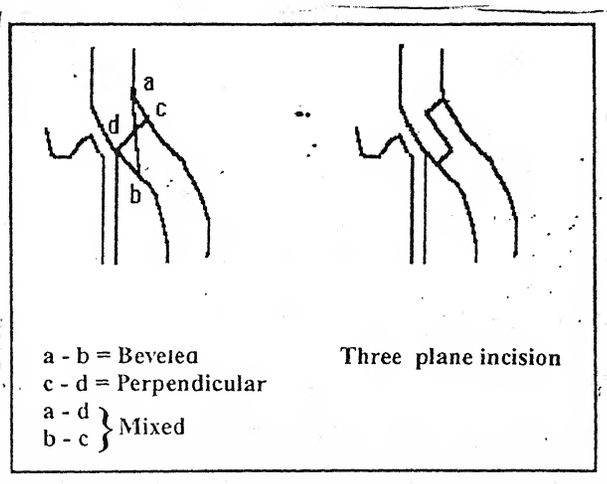
Salient features of wounds with different configurations

	Ease of construction	**Tendency for wound gape**
Perpendicular	++	+++
Beveled	++	++
Three plane	+	+

In conventional ECCE the curvilinear incision whereas in SICS it is sclerocorneal incision of three plane type. Three plane incision consists of:

1. External incision (making scleral groove)
2. Sclerocorneal pocket tunnel
3. Internal incision (Entry into the anterior chamber)

FIGURE 5. WOUND CONFIGURATION.



1. External Incision: (Figure 6)

The external configuration of scleral pocket tunnel incision may be straight or frown or inverted V type

Type	Advantages	Disadvantages
1. Straight incision	1. Easy to do 2. Best for beginners	More chance of ATR shift of astigmatism
2. Frown Shaped It is parabolic groove convex towards the limbus	1. Less postoperative astigmatism 2. Easy delivery of nucleus	Difficult to perform this incision
3. Inverted V shape	1. Less postoperative astigmatism 2. Easy delivery of nucleus	Difficult to perform this incision

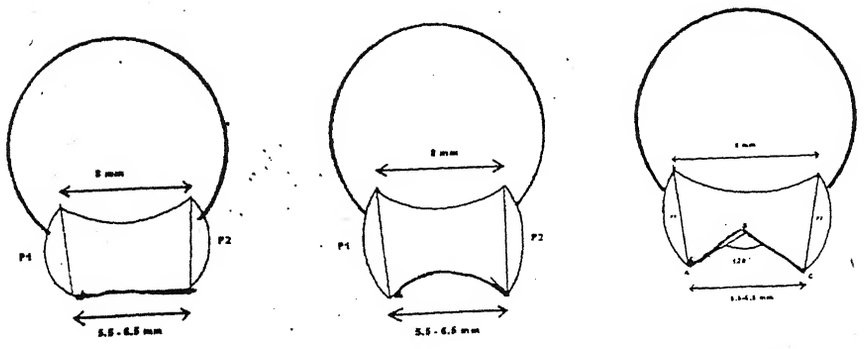
Frown shape and inverted V are the external incisions which have there ends running radially away from the limbus, which will prevent the sliding down of wound. Thus, preventing the ATR shift of astigmatism, whereas in straight incision, there may be chances of sliding down and ATR shift.

2.Internal Incision : (figure 7)

The inner incision should have following characteristics:

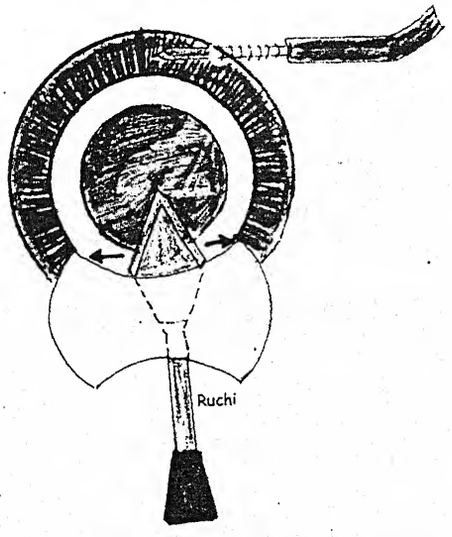
1. The inner incision should be 25% larger than the external incision.
2. The inner incision should be parallel to the limbus (therefore maintain the corneal configuration).

FIGURE 6. EXTERNAL INCISION.



Straight Frown Inverted "V"

FIGURE 7. INTERNAL INCISION.



3. It should be selfsealing by normal intraocular pressure (Ideally it can withstand the pressure upto 400 mm of Hg.

   Because of self sealing property there is no requirement of suture and suture related astigmatism post operatively.

2. **Wound Closure :** Closure of conventional ECCE wound

Healing of the cataract incision is more effective and rapid if the wound edges are held in accurate opposition during the first 4-5 days by sutures. The primary function of sutures is to keep the wound edges in accurate opposition.

Preplaced sutures by definition, are those that are placed prior to making the section. The advantage of these are that they appose corresponding points together and hence prevent lateral displacement or override of the wound edges which can cause astigmatism. The advent of microsurgery has greatly facilitated suturing by providing excellent visualization and high magnification. This has largely obviated the need for preplaced sutures.

THE MECHANISMS OF SUTURING

Sutures produce a zone of compression that equals the length of the suture. Hence, long sutures placed close to each other create significant tissue compression leading to with the rule astigmatism. Widely separated sutures, on the other hand, permit wound slippage and hence cause against the rule astigmatism. Sutures that are separated by a distance that equals their length cause minimal astigmatic change. Sutures 1.5 mm long are optimal for cataract surgery, with the length of the bites being equal on each side of the section.

a. Suture Tightness

Loose sutures permit wound edge separation and this leads to against the rule astigmatism. Optimal tightening of sutures apposes wound edges with minimal distortion of adjoining tissue.

b. Suture Depth

Sutures that are too superficial tend to cut through and permit wound edge slippage leading to against the rule astigmatism. Fine sutures, for example, 10-0 nylon, are ideally placed at 90% depth. Sutures that are less fine, for example, 8-0 silk, are placed at half-thickness depth. Thick sutures if placed deep can erode through due to necrosis of underlying tissue. The two lips of the wound should have the suture at the same depth for optimal apposition.

c. Suture Materials

Absorbable sutures cause premature or variable relaxation of the wound. They are hence not suitable for closure in cataract surgery. Of the nonabsorbable materials, silk often produces an inflammatory focus; this can cause tissue melting which induces wound relaxation. Nylon, mersilene, polypropylene, or steel wire sutures maintain the zones of compression throughout the wound healing phase and hence, are better materials for wound closure. Late (beyond 1 year) against the rule shift due to suture degradation tends to occur most with nylon and is least with mersilene and steel wire sutures.

d. Suture Orientation

Sutures should always be oriented radially. Nonradial sutures cause lateral displacement of the lips and hence lead on to astigmatism.

3. Healing Process:

The healing of a cataract is a dynamic process. The ultimate tensile strength of the wound depends on the integrity of the stroma. The initial healing of the stroma is completed by approximately six weeks ; therefore, if the Surgeon is to alter the wound, it should be done by this time. Wound remodeling may occur as late as several years after surgery.

Factors such as the general health and nutritional status of the patient and tropical steroid used may affect the ocular wound repair.

4.Postoperative Astigmatism after intraocular lens Implantation:

Ideally patients with IOL implants can get good post operative vision without glasses but postoperative astigmatism may make the result disappointing. Astigmatism, although primarily corneal in origin, may be produced when any element including the fovea, is not centered along the effective axis of the eye. It is found that postoperative astigmatism was proportionately far higher in the implant cases. The factors cited to explain this result were as follows:

(i) Irregular corneal healing

(ii) Decentration of implant

(iii) Optical error of implant

(iv) Weight of lens pulling on or distorting other intraocular structures.

(i). Irregular Corneal healing :

Any factors causing irregular corneal healing such as irregular incision, improper wound closure etc. can result in post operative astigmatism.

(ii). Decentration of implant :

The implant must be placed perpendicular to axis with its optical center on the axis. Failure to achieve this i.e. decentration will result in astigmatism. Decentration of the implant can be produced by rotation (tilt) of the lens implant along its optic and or translation (displacement) of implant perpendicular to its optic axis. The decentering of an implant is avoided by the careful centering of the implant at the end of surgery as the implant tends to stay in the position it has been placed. A slight decentering is of little importance, and it is surprising that vision frequently remains good even if the decentering is moderate. There is a tendency for the posterior chamber implant to tilt about the points of insertion, one end is often located in the lens capsule and the other end is located in the ciliary sulcus. The possibility of anteroposterior displacement also exists.

(iii). Optical error of implant :

In one study, Binkhorst concluded that astigmatism following lens implantation was due to the lens effectivity, an optical factor i.e. aberrations, alone.

(iv). Weight of lens pulling on or distorting other intraocular structures.

MANAGEMENT OF POST OPERATIVE ASTIGMATISM

The basic principles of correction of refractive error like Myopia and Hypermetropia are equally applicable to the correction of astigmatism errors. As in any ametropic correction, correction of the post operative astigmatism can be done by the following methods :

(i) Correction with spectacle lenses.

(ii) Correction with contact lenses.

(iii) Correction by surgical techniques includes –

a. Selective suture removal.

b. Corneal relaxing incision.

c. Corneal wedge resection.

Material & Methods

Material and Methods

The present study was conducted in the Department of Ophthalmology, Maharani Laxmi Bai Medical College, Jhansi.

In this study cases were selected from the cataract patients attending the eye Out Patient Department.

CRITERIA FOR SELECTION OF THE PATIENTS:-

Inclusion criteria :

1. Visually significant cataract, having visual acuity between hand movement to 6 / 36.
2. All patients were IOL candidates.
3. Reasonable visual potential.
4. IOL power between 16 – 24 Diopters.

Exclusion criteria :

1. Patients having complicated or traumatic cataract.
2. Patients having ocular disorders like Pterygium, Glaucoma, Corneal disorder, Squint or any posterior segment disorder.
3. Patients suffering from systemic disorders like hypertension, diabetes, ischemic heart disease, bronchial asthma or urinary problems.
4. Patients using steroids for long duration.
5. The patient undergone any intraocular surgery previously.
6. Children and very old persons (> 75 years) were excluded from our study.

All the patients were randomly assigned into two groups.

Group A: Patients underwent conventional procedures (Large Incision Extracapsular Cataract Extraction) with PCIOL. Incision size with 10 – 12 mm and wound closed with 10 – 0 nylon by interrupted suture technique.

Group B: The patients underwent sutureless, selfsealing, small incision (6 – 8 mm), cataract surgery with posterior chamber lens implantation.

In group B, subgroup comparison was done.

Subgroup B1: Incision size 6.5 mm vs. 8 mm horizontal in shape and placed at superoscleral area 2 mm from the limbus, WTR type of patients. 16 patients, 8 in each category.

Subgroup B2: Incision shape horizontal vs. frown 6.5 mm size placed at superoscleral area 2 mm from limbus, WTR type of patients. 16 patients, 8 in each category.

Subgroup B3: Incision location – superoscleral vs. temporal. 6.5 mm incision, frown in shape placed at superoscleral area for WTR patients and temporal site for ATR patients. 16 patients, 8 in each category.

PREOPERATIVE EVALUATION

Cataract patients were admitted 48 hours before the day of surgery.

A detailed history was taken and a comprehensive general examination was conducted and relevant investigations were

carried out. The Snellens visual acuity of patients was noted down (aided and unaided). Perception of light (PL) and projection of rays (PR) noted down by testing macular and peripheral retina respectively, by using pen torch light.

Slit lamp examination was done in all cases. Cases with raised intraocular pressure were excluded from the study. Patency of the lacrimal channel was confirmed by doing syringing. Foci of sepsis in the ear, nose, throat, teeth and lacrimal region were ruled out.

Whenever necessary, direct ophthalmoscopy, indirect ophthalmoscopy and non-contact biomicroscopy using + 90 D lens were done. In some cases, B-scan ultrasonography was done to rule out any posterior segment disorder.

Preoperative astigmatism noted by using Bausch and Lamb model keratometer.

A-scan biometry was done using the opticrom 2000 MIZOR model to establish the axial length. The IOL power was calculated by using SRK II (Sanders, Retzlaff and Kraff) formula[61,62].

$$P = A - 2.5\,L - 0.9\,K$$

P = power of IOL in Diopters

A = Constant specific for lens

L = Axial length of the eye ball

K = Average keratometry reading in Diopters

PREOPERATIVE PREPARATION

- Informed and written consent was taken.
- Part prepared (trimming of eye lashes).

- Xylocaine sensitivity was done.
- Tab. Ciprofloxacin 500 mg 1 HS and 1 CM
- Tab. Alprazolam 0.25 mg 1 HS and 1 CM
- Cap. Indomethacin 25 mg 1 HS and 1 CM
- Tab. Acetazolamide 250 mg 2 HS and 2 CM (only in large incision ECCE cases)
- Eye drop Ofloxacin 3 hourly from 10 a.m. to 10 p.m.

Pupil dilatation was achieved with
- Eye drop Tropicamide 1% + Phenylephrine 10%
- Eye drop Flurbiprofen 0.03%

} 2 hours before surgery

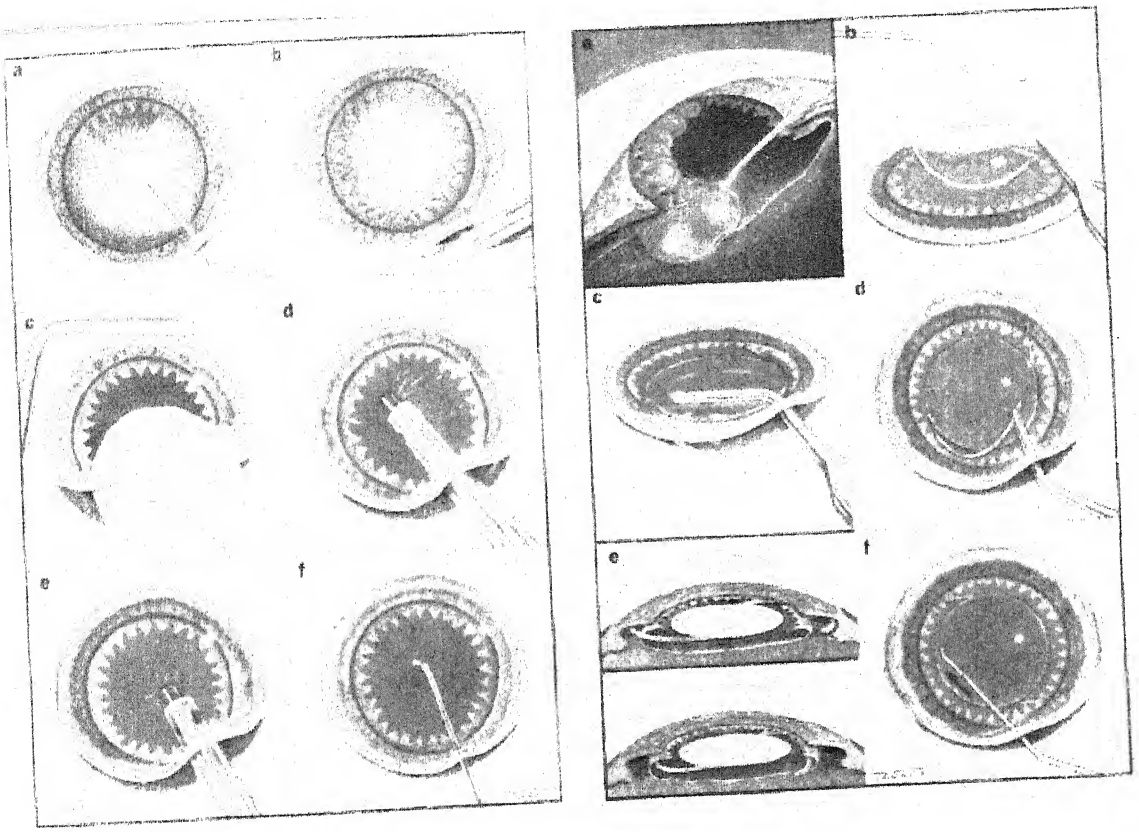
ANESTHESIA : Local anesthesia was used in all cases. 8 ml solution of 2% lignocaine HCl with 1 : 1,00,000 adrenaline with hyaluronidase (3.75 - 7.5 turbidity units / ml) was used for peribulbar block. After injecting solution, ocular massage and super pinke was tied on to the eye, after putting an eye pad on the eye. This ocular massage was done only for large incision extracapsular cataract surgery not for small incision surgery cases.

A 5% povidone iodine solution was used for cleaning of eyelids and conjunctival sac, then conjunctival sac was washed with balanced salt solution (BSS).

Group 1: SURGICAL PROCEDURE OF LARGE INCISION NUCLEAR EXPRESSION CATARACT SURGERY (LINECS)

1. Hypotony of eye ball was achieved with 2 Tab. Acetazolamide 250 mg and ocular massage.
2. Superior rectus bridle suture was applied, and fornix based conjunctival flap was done and retracted back. Haemostasis was achieved with a wet field electro cautery.

CONVENTIONAL EXTRA CAPSULAR CATARACT EXTRACTION WITH POSTERIOR CHAMBER IOL IMPLANTATION



3. A limbal gutter was made with a surgical blade number 11. Extending from 2 O'clock position to 10 O'clock position, approximately 10 – 12 mm in size.
4. Anterior chamber perforated at 12 O'clock position of gutter by blade. A viscosurgical substance (hydroxy propyl methyl cellulose 2%) was injected.
5. Anterior capsulotomy performed by using cystitome (a double bent 26 gauge needle fixed to 2 ml syringe with BSS).
6. The section was completed by corneoscleral scissors.
7. Hydroprocedures : hydrodissection was done by injecting balanced salt solution between anterior capsule and cortex of the lens.
8. Lens nucleus was expressed with the help of lens expresser and wire vectis (modified Indian Smith technique).
9. Removal of the remaining cortex using an irrigation- aspiration simcoe cannula.
10. Posterior chamber IOL was put in a capsular bag under the cover of visco-surgical substance.
11. The corneoscleral wound margin was closed with 10 – 0 nylon, 6 – 8 interrupted suture, after injecting air into the anterior chamber.

Group 2: In this group patients underwent small incision cataract surgery of incision size (6 or 8 mm) and shape (frown or horizontal), site (superoscleral or temporal) with occasional suture.

SURGICAL PROCEDURE OF SMALL INCISION CATARACT SURGERY (SICS)

1. Anesthesia : Peribulbar anesthesia was used in all cases. Intraocular pressure was kept at normal or slightly higher level,

Steps of Surgery in Manual SICS by Irrigating Vectis

Photo 1: Conjunctival flap

Photo 2: External incision

Photo 3: Internal incision

Photo 4: Scleral pocket

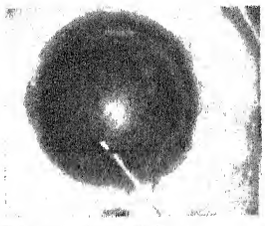


Photo 5: Capsulorhexis

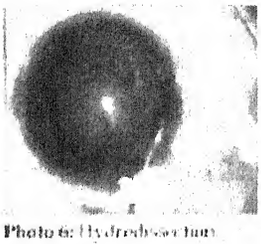


Photo 6: Hydrodissection

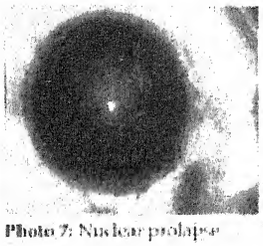


Photo 7: Nuclear prolapse

Photo 8: Nucleus delivery

Photo 9: Nucleus delivery

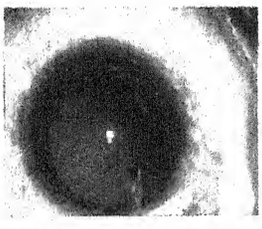


Photo 10: Cortical cleaning

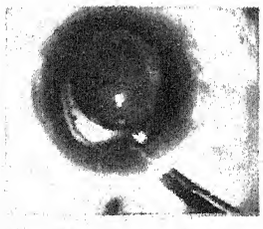


Photo 11: PC IOL in-the-bag

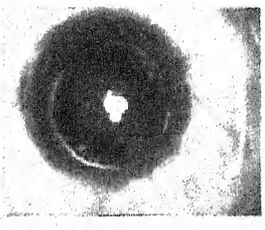


Photo 12: Wound closure

by avoiding tab. Acetazolamide preoperatively and excessive ocular massage after giving peribulbar block.

2. Superior rectus bridle suture was applied, and fornix based conjunctival flap was done and retracted back. Haemostasis was achieved with a wet field electro cautery.
3. Incision :

(a). External incision : Horizontal scratch incision of 6.5 mm in size, placed superiorly 2 mm away from the limbus, by using guarded surgical blade (0.3 mm depth).

(b). Sclerocorneal tunnel incision : This 3 plane scleral tunnel dissection done by 2.8 mm angled crescent knife upto 2 mm in the corneal stroma. Inner pocket dissection in the cornea is greater than the outer incision.

4. Visco-surgical substance (hydroxy propyl methyl cellulose 2%) was injected into the anterior chamber through the side port.
5. Anterior capsulotomy (can-opener technique) was done by using cystitome (26 gauge needle).
6. Deeper anterior chamber with visco-elastic substance, enter into anterior chamber through predissected tunnel incision by 3.2 mm angled keratome. Taking care that corneal inner incision was done while entering into the anterior chamber, not while coming back. To avoid failure of inner selfsealing valve.
7. Hydroprocedures :

   Hydrodissection, this is done by injecting balanced salt solution (BSS) between anterior capsule and cortex of the lens.

   Hydrodelineation, this is performed by injecting balanced salt solution between epinucleus and nucleus of the lens.
8. By doing hydroprocedures, nucleus comes out of the capsular bag into the anterior chamber. Visco-elastic substance injected

infront and behind the nucleus, i.e. nucleus in the ocean of visco-elastic.

9. Using irrigating vectis (3 ports) nudging the nucleus, superiorly and anteriorly. Delivery of the nucleus, from anterior chamber to the outside was done by withdrawing irrigating vectis simultaneously injecting visco-substance into the anterior chamber, i.e. **visco-expression.**
10. The remaining epinucleus and cortical matter was removed by using simcoe cannula (irrigation - aspiration cannula). Balanced salt solution (BSS) as the irrigating fluid in a bottle at a height of 40" (inches) above the eye level.
11. Posterior intraocular lens (PCIOL) was placed in the capsular bag under the cover of visco-surgical substance using McPherson forceps.
12. Usually the incision was selfsealing, so occasionally need of one or two interrupted radial sutures arises.

POSTOPERATIVE EVALUATION

A detailed examination was done on the 1st and 2nd postoperative day. 3rd day patients were discharged. Subsequent examination was done on the 1st week and 6th week.

Factors studied were:

1. Astigmatism.
2. Visual acuity.

Spectacle correction was given at the end of 6 weeks and final aided visual acuity noted.

Evaluation of surgically induced astigmatism: The preoperative and postoperative astigmatism can be measured directly, using an

automated or manual keratometer, but the surgically induced astigmatism needs to be calculated. Keratometry measures only corneal astigmatism, but since this is the only component of astigmatism that can be readily manipulated, the values are clinically relevant.

The plus cylinder format: Astigmatism is generally recorded in the form of a plus cylinder. The magnitude of astigmatism is equal to the difference in keratometric (Dioptric) values, and its axis is identical to that of the steeper meridian.

Calculating Surgically Induced Astigmatism (SIA): There are many techniques of calculating SIA 1. Simple substraction method, 2. Algebric substraction method, 3. Vector analysis, 4. Cortesian co-ordinate method and others.

Simple Subtraction Technique: The simple subtraction technique uses just the Dioptric values, while totally ignoring the axis of astigmatism. SIA equals Dioptric postoperative astigmatism minus Dioptric preoperative astigmatism. Because it ignores the axis, this method is incorrect and obsolete.

Algebraic Subtraction Technique: The basic equation remains the same, that is; SIA equals postop minus preop astigmatism, but here the pre and postop astigmatic values are assigned a particular sign according to whether they are with the rule (plus) or against the rule (minus). The SIA is then calculated with the appropriate signs appended, and sign of the resultants tells you whether you induced with or against the rule astigmatism. The method is only partially accurate. This method is used in this study and statistically analyzed the results.

WORKING PROFORMA FOR STUDY

***Topic**: Estimation of Visual acuity and astigmatism after cataract surgery.*

Case No.	OPD. No	MRD. No
Name of patient.		Date of Admission
Age		Date of Surgery
Sex		Date of discharge
Occupation		
Address		

Chief complaints

1. Diminution of vision.
2. Redness/ watering / pain.
3. Coloured halos, glare and other complaints.

History of present illness

Past History

- Trauma / previously undergone surgery
- Hypertension / diabetes / pulmonary tuberculosis

Family History

Personal History

Examination

General Health- Good / Fair / Poor

Systemic examination-

1. CVS	Blood pressure
2. CNS	Pulse rate
3. Respiratory system	
4. Perabdomen	

Occular examination

- Head position
- Fascial symmetry
- Forehead

	Right eye	**Left eye**
Eyelids, eyelashes		
Conjunctiva		
Cornea		
Anterior chamber		
Iris		
Pupil		
Lens		
Vision		
Syringing		
Tension		
Extraocular movements		

Investigations

Random blood sugar

Biometry

Keratometry

	Pre op	Post op 1st week	Post op 6th week
K1 (Diopters)			
K2 (Diopters)			
Axial length (mm)			
Posterior chamber IOL (D)			

Observations

Observations

In this study, 120 patients were included. The cases were divided randomly into two groups.

Group A: Consisting of 60 patients, who underwent large incision cataract extraction with posterior chamber intraocular lens implantation. The incision is closed with 10 - 0 polyamide nylon, interrupted pattern.

Group B: Consisting of 60 patients, who underwent small incision cataract surgery with posterior chamber intraocular lens implantation of incision size 6.5 mm.

Observations

Sex distribution

In the total 120 patients, males were 75 and females were 45 Male : Female sex ratio was 1.6 : 1.

Table 1

Sex distribution

Sex	Group A (LIECCE) (n=60)	Group B (SICS) (n-60)	Total No. (%)	Preop astigmatism (Mean)	Postop astigmatism (Mean)
Female	25 (41.66%)	20 (33.3%)	45 (37.5%)	0.86 D	1.03 D
Male	35 (58.33%)	40 (66.71%)	75 (62.5%)	0.92 D	1.06 D

The majority of patients were males in both the groups.

Table 1. Sex Distribution

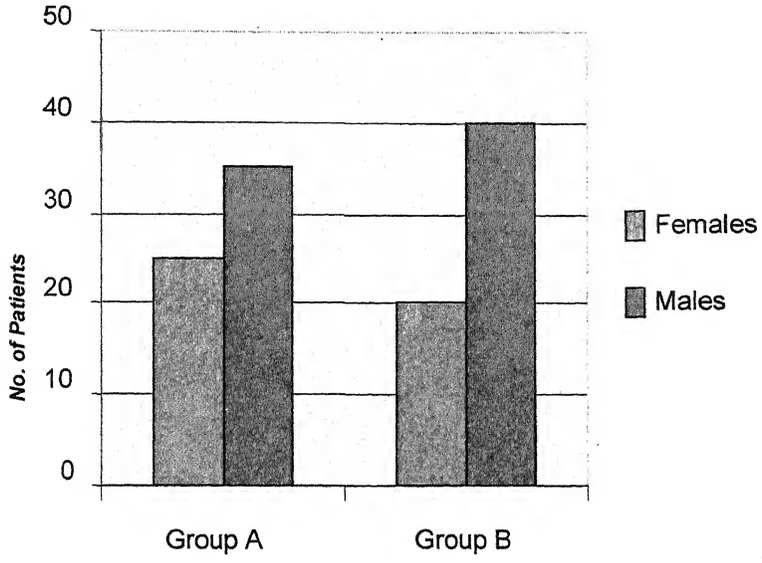


Table 2. Age Distribution

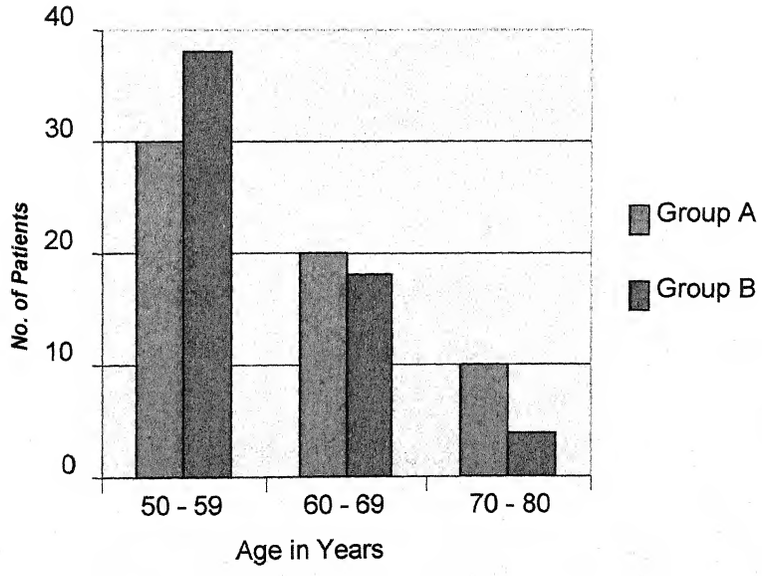


Table 2

Age distribution.

Age in Years	No. of patients (n=120)	No. of patients with percentage	
		Group A(n-60) (LIECCE)	Group B(n-60) (SICS)
50 – 60	68 (56.66%)	30 (50%)	38 (63.3%)
61 – 70	38 (31.66%)	20 (33.3%)	18 (30%)
71 – 80	14 (11.66%)	10 (16.7%)	04 (6.7%)

The above table shows that the majority of patients belonged to the age group of 50 – 60 years in both the groups, i.e. 68 patients (56.66%).

Table 3

Base line variables in two groups

Base line variable	Group A	Group B
Mean age (in years)	57 ± 6.6	58 ± 6.16
Sex ratio (M : F)	1.2 : 1	2: 1
Pre-operative astigmatism (in Diopters)	0.5 D	0.6 D

VISUAL ACUITY

Table 4

Pre-operative visual acuity

Visual acuity	No. of patients (n=120)	No. of patients and percentage	
		Group A	Group B
		60 patients	60 patients
6 / 36 or less	25 (20.83%)	10 (16.66%)	15 (25.00%)
Finger counting	70 (58.33%)	38 (63.33%)	32 (53.33%)
PL + , PR+	25 (20.83%)	12 (20.00%)	13 (21.66%)

The majority of patients having visual acuity in the range of finger counting at 1 metre or less, in the Group A it is approximately 63.33% (i.e. 38 patients) and in Group B 53.33% (i.e. 32 patients) belong to this category.

Table 4. Pre-operative visual acuity

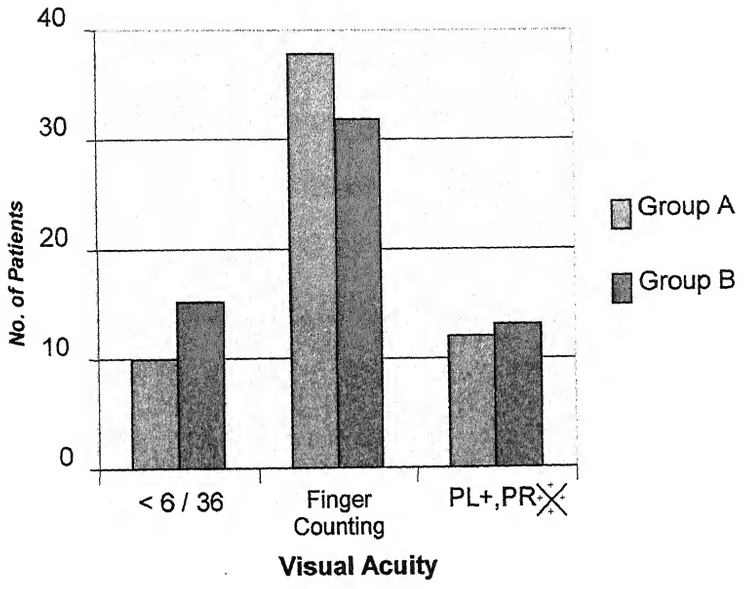


Table 5. Postoperative visual acuity at 1st week

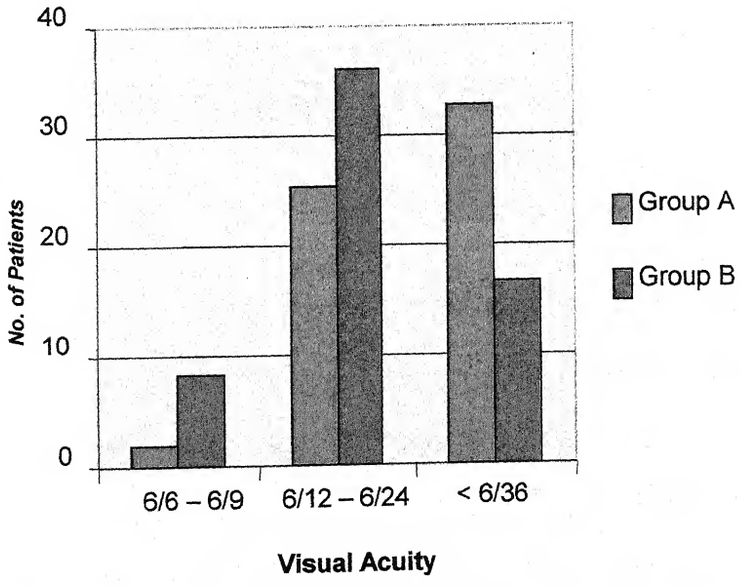


Table 5

Post operative visual activity at 1st week.

Visual acuity	Group A(n-60)	Group B(n-60)
6 / 6 - 6 / 9	2 (3.33%)	8 (13.33%)
6 / 12 - 6 / 24	25 (41.66%)	36 (60.00%)
6 / 36 - less	33 (55.00%)	16 (26.67%)

The above table shows that UCVA at 1st week. Here upto 33 patients (55%) in Group A have UCVA 6 / 36 and only 2 people got the target visual acuity 6 / 6 or 6 / 9 at 1st week. Whereas in Group B (SICS) cases, 8 patients (13.33%) got the UCVA of 6 / 6 or 6 / 9. Majority of patients (60%) in this group attained the UCVA of 6 / 12 – 6 / 24 at the end of first week.

The post operative visual acuity at 6th week was considered as the end point of our follow up. The post operative period of 6 weeks is enough time for the wound to get healed and attain normal strength.

Table 6

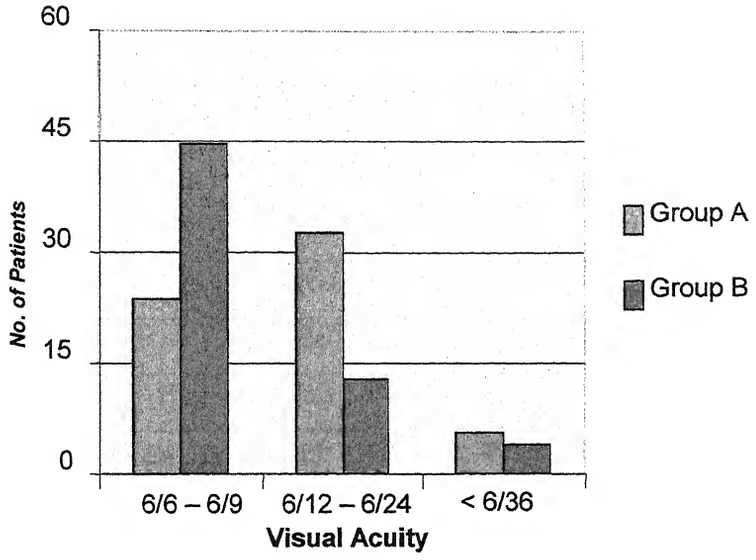
Post operative visual acuity UCVA and BCVA at 6 weeks.

Visual Acuity	Group A (LIECCE)		Group B (SICS)	
	UCVA	BCVA	UCVA	BCVA
6 / 6 - 6 / 9	23 (38.33%)	40 (66.66%)	45 (75.00%)	54 (90.00%)
6 / 12 - 6 / 24	33 (55.00%)	16 (26.66%)	12 (20.00%)	05 (08.33%)
6 / 36 - less	04 (6.67%)	04 (6.66%)	03 (05.00%)	01 (01.67%)

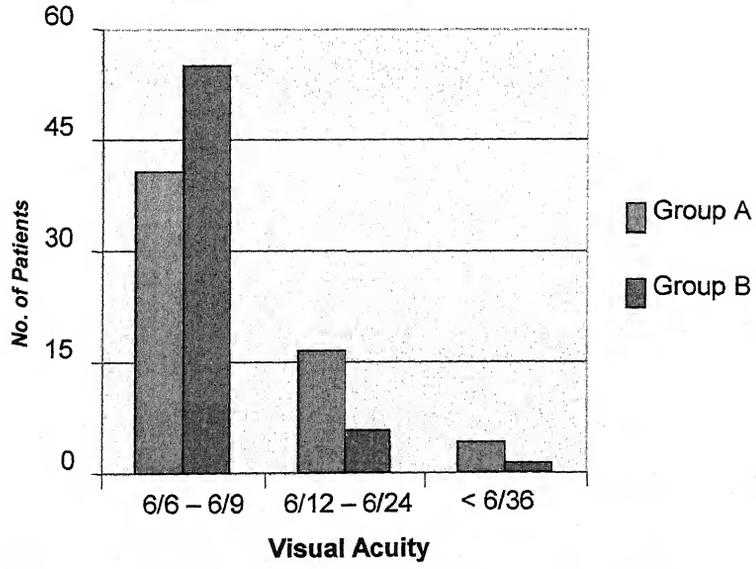
At the end of 6 weeks follow up, in Group A majority of 33 (55%) cases have UCVA of 6 / 12 – 6 / 24 and 23 (38.33%) cases attained targeted visual acuity 6 / 6 – 6 / 9, without the help of glasses. 17 cases (28.33%) with the help of glasses, they attained the visual acuity 6 / 6 from 6 / 12 or less, so in Group A 40 patients (66.66%) attained the visual acuity 6 / 6 – 6 / 9. SICS patients attained better visual acuity compared to SICS group ($p < 0.05$).

Table 6. Postoperative visual acuity at 6th week

(uncorrected visual acuity- UCVA)



(Best corrected visual acuity- BCVA)



In Group B, majority of patients 45 (75%) attained 6 / 9 or 6 / 6 without the aid of glasses. Only 9 cases (0.5%) requires some correction to attain 6 / 6 vision, so upto 90% of cases have BCVA 6/6 or 6 / 9 whereas it is only 66.66% cases in Group A.

ASTIGMATISM CHANGES

Table 7

Pre-operative keratometric astigmatism.

Astigmatism in Diopters	Group A (LIECCE)	Group B (SICS)
Nil	4 (6.66%)	6 (10.00%)
< 1 D	36 (60.00%)	32 (53.33%)
1 – 2 D	20 (33.33%)	22 (33.66%)

Preoperative astigmatism present in 110 cases out of 120 cases i.e. upto 91.66%, and astigmatically neutral patients were only 10 cases i.e. 8.33%. Here significant degree of astigmatism already exists.

Table 8

Type of pre-operative astigmatism

Type of astigmatism	No. of patients	Group A (LIECCE)	Group B (SICS)
Nil	10 (8.33%)	4 (6.6%)	6 (10%)
WTR	74 (61.66%)	38 (63.33%)	36 (60%)
ATR	36 (30.01%)	18 (30%)	18 (30%)

Among 120 cases 74 patients shows WTR type of regular astigmatism, and 36 patients ATR of variety, and only 10 cases were astigmatically neutral. Thus, it shows the importance of pre-operative astigmatism.

Table 7. Preoperative keratometric Astigmatism

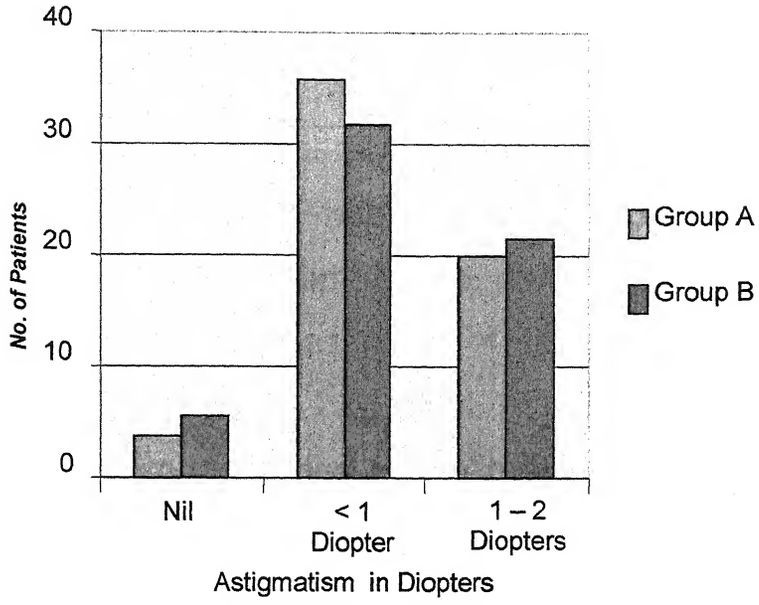


Table 8. Types of Preoperative Astigmatism

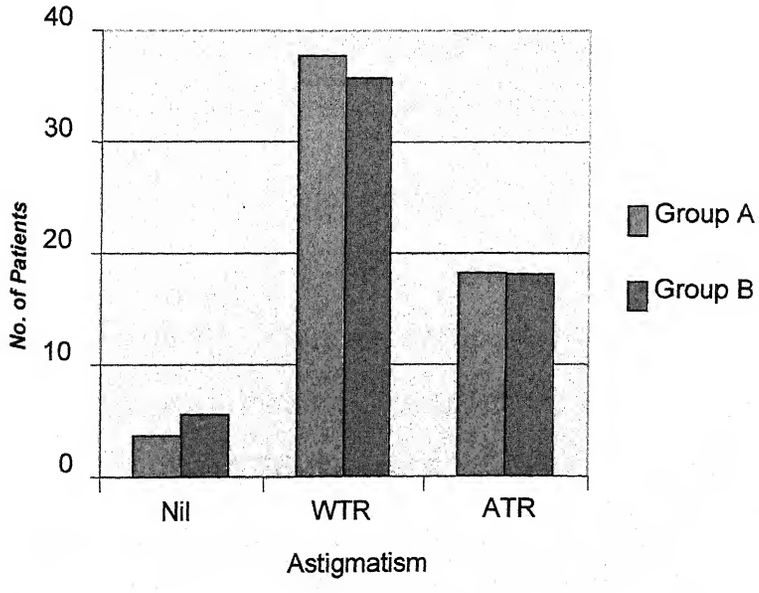


Table 9

Post-operative astigmatism at 1st week

Astigmatism	Group A (LIECCE)	Group B (SICS)
Nil	0	2 (3.3%)
< 1 D >	2 (3.3%)	15 (25%)
1.25 D – 2 D	15 (25%)	23 (38.33%)
> 2 D	43 (71.67%)	10 (16.66%)

The pattern of post operative astigmatism significantly varies between the Group A and Group B, in Group A majority of patients having (71.67%) astigmatism in the order of 4 – 5 Diopters, whereas in Group B cases most of the patients having the astigmatism in between 1 – 2 Diopters. At the end of 1st week only 2 cases in SICS group attained astigmatically neutral vision.

Table 10

Post operative astigmatism at 6 weeks

Astigmatism	No. of patients	Group A (LIECCE) (n-60)	Group B (SICS) (n-60)
Nil	41 (34.16%)	3 (3.3%)	38 (63.33%)
< 1 D	28 (23.33%)	14 (23.33%)	14 (23.13%)
1 – 2 D	31 (25.83%)	26 (43.33%)	5 (8.33%)
> 2 D	20 (16.66%)	17 (28.33%)	3 (3.33%)
SIA [mean ± SD]		**1.44 ± 1.26**	**0.76 ± 0.69**

At the end of 6 weeks, SICS incision group patients showed slightly lower astigmatic changes compared to large incision group ($p < 0.05$). In large incision group the patients were having astigmatism of 1.44 ± 1.26 Diopters, in Group B patients having a astigmatism of 0.76 ± 0.69 D.

Table 9. Postoperative Astigmatism at 1st week

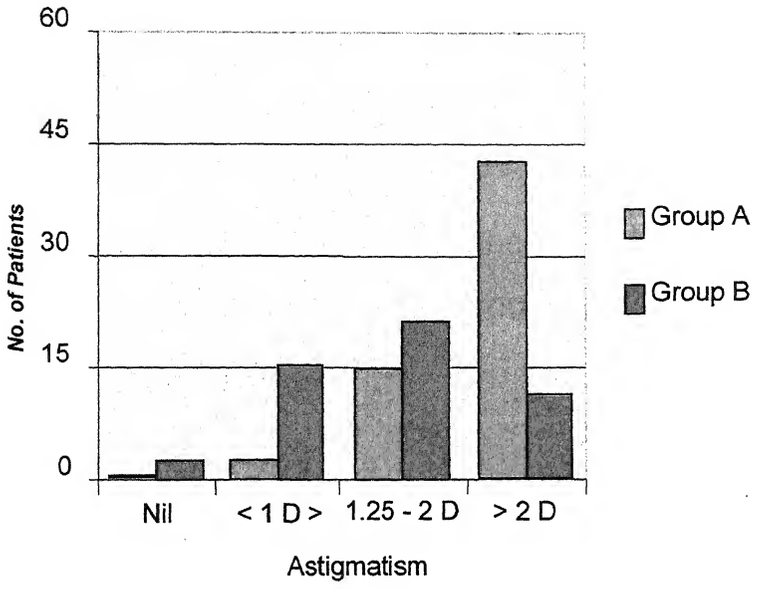


Table 10. Postoperative Astigmatism at 6th week

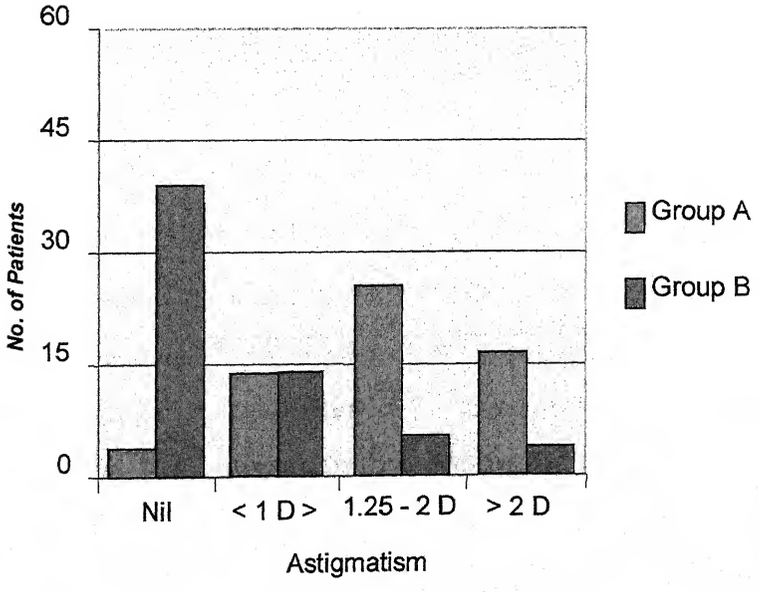


Table 11a

Type of post operative astigmatism at 6 weeks

Type of astigmatism	Group A (LIECCE)	Group B (SICS)
Nil	3 (3.33%)	22 (36.66%)
WTR	38 (63.33%)	21 (35%)
ATR	19 (33.33%)	17 (28.33%)

Above table shows the astigmatically neutral is achieved only in 25 patients, out of 120 patients, i.e. 41.66%. 59 patients showed WTR astigmatism in comparison with 36 patients of ATR type. This difference is marked in large incision group but less in small incision group.

Table 11b

Type of SIA after 6 weeks

Type of astigmatism	Group A (LIECCE)	Group B (SICS)
Nil	4 (6.00%)	10 (16.66%)
WTR	22 (36.66%)	30 (50%)
ATR	34 (56.66%)	20 (33.33%)

Above Table shows that 56.66% of patients in Group A shifted to ATR type whereas 50% patients in SICS Group shifted to WTR type.

Table 12

Incision size 6.5 mm vs. 8 mm.

Incision size	Preoperative astigmatism in Diopters	1st week post-operative astigmatism	6th week post-operative astigmatism	SIA Mean ± SD
6.5 mm	1.59 D	1.625 D	0.6718 D	0.51 ± 0.26
8 mm	1.06 D	1.25 D	0.906 D	0.78 ± 0.82

Table 11. Types of Postoperative Astigmatism at 6th week

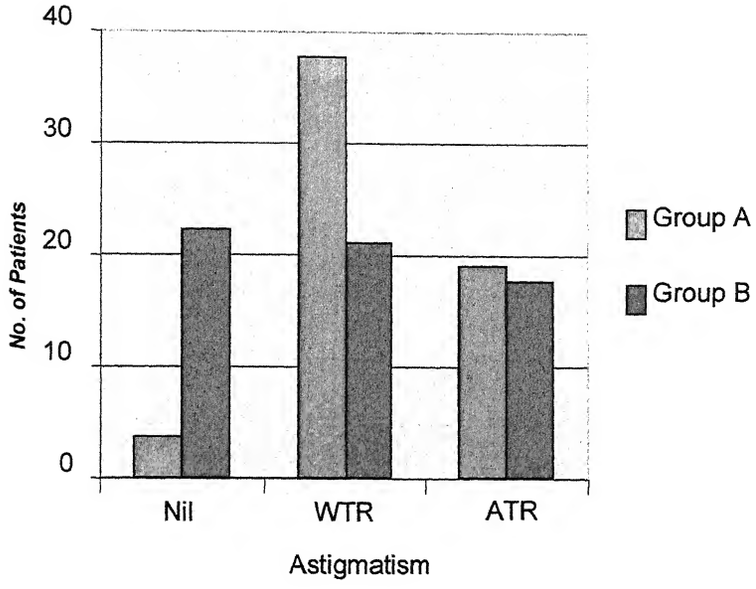
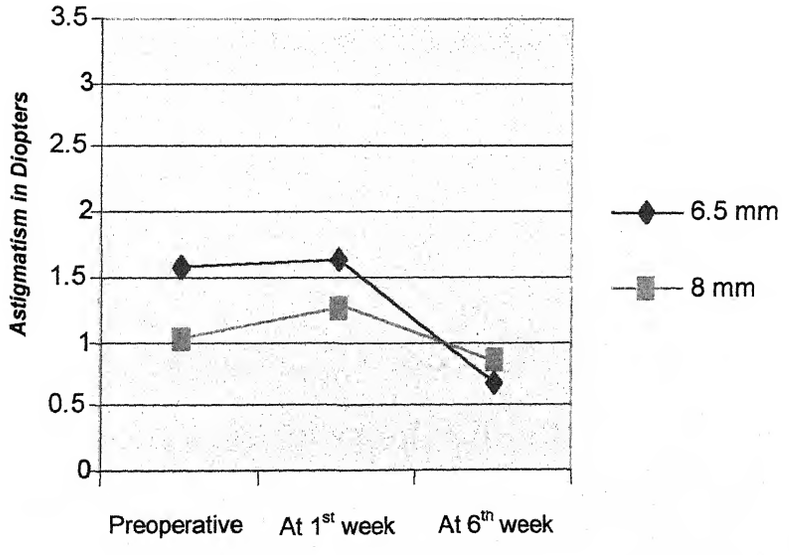


Table 12. Incision Size & astigmatism changes



The above table depicts 6.5 mm and 8 mm incision shows the surgically induced astigmatism of 0.51 D ± 0.26 D and 0.78 ± 0.82 D astigmatism changes respectively, which is statistically significant ($p < 0.05$).

Table 13

Incision shape Horizontal vs. Frown

Incision Shape	Preoperative astigmatism in Diopters	1st week post-operative astigmatism	6th week post-operative astigmatism	SIA Mean ± SD
Horizontal	0.46 D	1.65 D	0.6769 D	0.51 ± 0.26
Frown	1.59 D	1.625 D	0.6718 D	0.48 ± 0.15

The above table shows that, frown shaped external incision statistically significantly controls the surgically induced astigmatism (0.48±0.15 D)compared to horizontal shape incision (0.51 ± 0.26D).

Table 14

Location of Incision superoscleral vs. temporal

Incision location	Preoperative astigmatism in Diopters	1st week post-operative astigmatism	6th week post-operative astigmatism	SIA Mean ± SD
Superoscleral incision	1.59 D	1.625 D	0.6718 D	0.48 ± 0.15
Temporal incision	1.03 D	1.9 D	0.3425 D	0.36 ± 0.4

The above table shows that the temporal incision attains surgically induced astigmatism of 0.36 ± 0.4 D and superoscleral incision attains 0.48 ± 0.15 D. So significant ($p < 0.05$) difference exists between them.

Table 13. Incision Shape & astigmatism changes

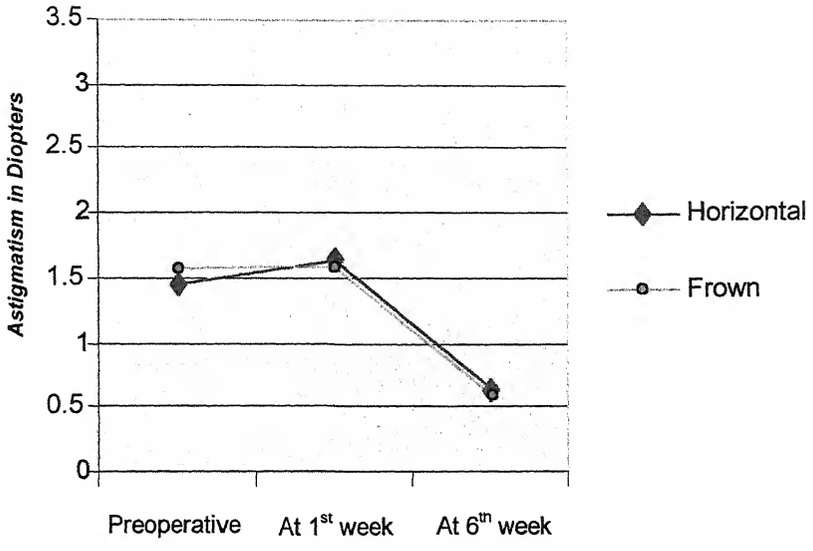
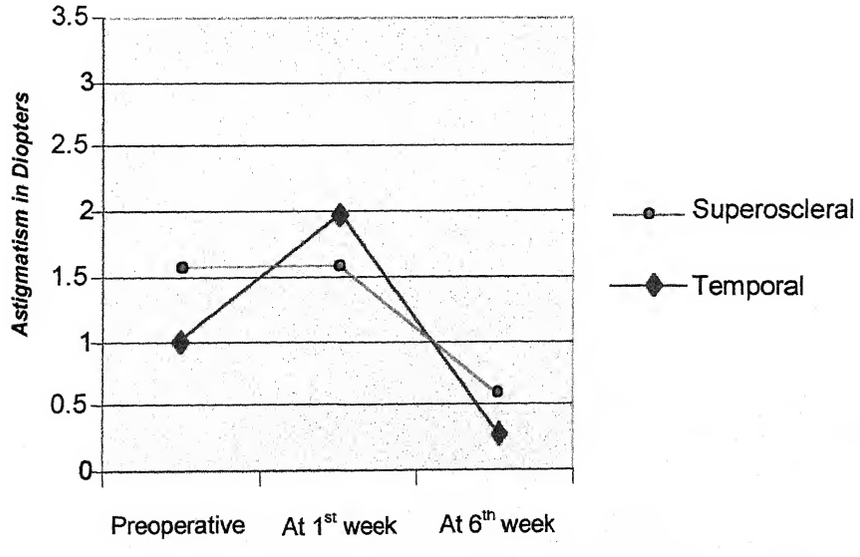


Table 14. Incision Site & astigmatism changes



Discussion

Discussion

In this study, 120 patients were included who underwent cataract extraction in the Department of Ophthalmology, M.L.B. Medical College, Jhansi, during the period between 1-6-2002 to 1-6-2003, concurrently the patients were followed up at 1st week and 6th week postoperatively, during this period.

Sex : (Table No. 1) In this study the sex distribution was in the favour of males. The Male : Female ratio is 1.6 : 1. The probable cause of such ratio difference is due to the social setup, generally female patients do not attend the hospital.

Nirmalan DK, Padmawati, Tulsiraj RD in their study of "Sex inequalitis in cataract blindness burden and surgical services in South India", females were less likely to be operated for cataract, otherwise cataract blindness burden was higher for females. Literacy of the subject was a major predictor for being operated.

Lewallen S, Cowtight et al. "Study of gender and use of cataract surgical devices, in developing countries", shows cataract surgical coverage rate was 1.2 – 1.7 times for males than for females. It is almost similar to our study.

The amount of astigmatism is similar in both sexes, so it does not vary with sex.

Age : (Table No. 2) The majority of patients were in the age group of 50 – 60 years. It comprises about 56.66% i.e. total 68 patients out of 120 patients.

Eye affected : The amount of astigmatism was similar in both the eyes, so it does not vary much with the eye affected right or left eye.

Visual acuity : (Table No. 4) In this study majority of patients operated were having visual acuity of finger counting, but the range is extending from 6 / 36 to PL+ and PR+

Monestame, Tabackman B, Richter, Loundstom studied visual function impairment on the postoperative visual outcome.

Jay JL, Mammo RB, Alleno D showed vision after operation varied from a mean value of 6 / 5 at 50 years to 6 / 12 at 90 years, a decline of one line for every 13.4 years.

In this study majority of patients 70 (58.3%) operated having a visual acuity of finger counting, functionally impairment is the main reason for operation. In the first postoperative week (Table No. 5), 61 patients (50.8%) got good visual acuity of 6 / 12 to 6 / 24. At the end of six weeks (Table No. 6) postoperative period, 94 patients (78.33%) got visual acuity of (BCVA) in the range of 6 / 6 – 6 / 9. 54 patients (90%) of group B and 40 patients (66.6%) of group A achieved BCVA 6 / 6 – 6 / 9. The inequality in achievement of the target vision may be due to the factors like preoperative visual acuity and astigmatism, intra operative incision, suture or complications and postoperative wound healing.

Tobackman JK, Zimmerman B et al. Study of visual function impairment in relation to the gender, age and visual acuity in patients undergoing cataract surgery was done. They concluded that when deciding whether to perform cataract surgery, functional impairment must be considered in relation to the age and gender of the patient. For the type of functional impairment varies in association with age and gender.

Astigmatism : According to Table No. 7, the preoperative astigmatism present in 110 cases out of 120 cases, i.e. upto 91.66%. Significant amount of astigmatism already exist so preoperative astigmatism evaluation is a must before doing cataract surgery. Cataract surgery gives an opportunity to reduction of preexisting astigmatism. Most patients in both the groups were having astigmatism less than 1 Diopters.

The incidence of preoperative astigmatism reported by some others : 10.56% (Mugge, 1908), 42% (Nirankari and Khanna), 7.47% (Luhl, 1909), 44.39% (Cavare, 1922), 14.10% (Leibowiez, 1928), 60% (Kapoor, 1965), 79% (Beasley, 1967), 95% (Duke Elder, 1949), 69% (Singh and Goel, 1969) and 24% (Vasavada and Swalichapan, 1989).

In the present study the average astigmatism was 0.86 Diopters, it is almost similar to 0.75 Diopters by Pflaz (1885), 1 Diopters by Donders (1864), 1.04 Diopters by Jackson (1932) and 0.97 Diopters by Kapoor (1965), but slightly higher than 0.5 Diopters by Srensen (1944) and 0.5 to 0.75 Diopters by Duke Elder (1949).

Post operative results shows the amount of astigmatism varies between two groups.

At the end of first week (Table No. 9) majority of patients 71.67% in Group having astigmatism in order of 4 – 6 Diopters and in group B 23 cases (38.33%) it is of 1 – 2 Diopters. The tendency for with-the-rule type of astigmatism to increase postoperatively seen in large incision group patients, may be due to sutural phenomenon as first described by Floyd (1951), and later by Beasley (1967) and Elenius & Karo (1968).

At the end of 6th week (Table No. 10) of post operative period large incision group patients show slightly higher astigmatic changes compared to small incision patients.

In large incision group, majority of patients having the astigmatism of 1.44 ± 1.20 Diopters, whereas in small incision cases most of the patients had attained astigmatism of 0.76 ± 0.69 Diopters. It is similar to results of other studies for conventional ECCE cases (12 mm) - Leen et al (2.58 D). Neumann et al (2.27 D), Oshika (1.32 D), Werblin (1.9 D).

In small incision cases (6 mm), Davison (0.41 D), Gills, Sanders (2.27 D), Martin (0.8 D), Neumann (1.06 D), Oshika (0.48 D), Steinert (1.44 D), Werblin (1.0 D).

From the above observation, it shows that the postoperative astigmatism is higher in the conventional ECCE cataract surgery compared to the small incision cataract surgery cases. This is due to multiple variables like – incision size, shape, site, use of suture and postoperative wound healing.

Table No. 8 and Table No. 11 shows that there is a ATR shift of astigmatism occurred in Large Incision group, whereas it is WTR type in SICS group. Some studies (Neilson, Oshima et al, Pfieger) shows that after longer period of follow up, even SICS cases ATR drift can occur.

In small incision cases (Group B), subgroup B1 – As the incision size decreases, there is corresponding decrease in astigmatism occurred. 6.5 mm and 8 mm incision size shows corresponding decrease in the astigmatism 0.6718 (0.51 ± 0.26) and 0.906 (0.78 ± 0.82) D respectively (Table No. 12).

Similar type of results were seen with other studies – Ander N, Pham DT (1997), Akura J, Kaneda S, Halta S (2000), Martin M

Leen, Myron Yanoff (1992), Vazquez LA, Panesso JL (1993) (9 vs. 6 mm), Dam, Johanenm, Olsen T (1997) (4 vs. 6 mm) (0.61 Diopter and 0.77 Diopter).

Subgroup B2, incision shape - frown external incision shape (0.48 ± 0.15) is better than horizontal incision (0.51 ± 0.26) in controlling astigmatism postoperatively (Table No. 13). Many studies have achieved this type of results – Singer JA (1991), in his study of horizontal vs. frown shaped got 1.15 Diopters and 0.84 Diopters respectively after 3 months.

Subgroup B3, incision site – temporal incision (0.36 ± 0.4 D) location is better in controlling surgically induced astigmatism, compared to superoscleral incision (0.48 ± 0.15 D)(Table No. 14). This result is comparable to the results of Ander et al (0.93 (s); 0.7 D (t)), Wirblauer et al (1.76 (s); 1.53 D (t)), Anders N, Pham DT (1997) (1.31 (s); 0.84 D (t)), Akura J, Kaneda S, Hatta S, Matsura K (0.64 (s); 0.5 D (t)).

Thus, from the above it is evident that extracapsular cataract extraction with posterior chamber lens implantation using the scleral tunnel, sutureless, selfsealing, small incision is safe and more effective (visual acuity and post operative astigmatism) method than the conventional large incision procedure, giving a good visual outcome, lesser surgically induced astigmatism and an early rehabilitation.

Summary

Summary

The present study was undertaken to compare the surgically induced astigmatism and final postoperative visual acuity in patients undergoing extracapsular cataract extraction with posterior chamber implantation through conventional large incision and small incision cataract surgery.

120 patients were selected who had undergone cataract extraction in the Department of Ophthalmology, M.L.B. Medical College, Jhansi. Patients were divided into two groups of 60 each. Group A, 60 patients undergone conventional ECCE and Group B, 60 patients undergone Small incision cataract surgery with different incision size, shape and site, in the sub-group comparison.

Preoperative Snellen visual acuity, keratometry and A-Scan biometry was done and calculated power of intraocular lens (SRK-T) implanted.

Post operative evaluation was done at the end of 1st week and 6th week. During this visit, visual acuity (UCVA and BCVA) and postoperative keratometry reading was noted down.

The results obtained showed that there was a general trend of surgically induced astigmatism towards against – the – rule (ATR) with steepening of the horizontal meridian in conventional procedure, as compared to flattening of vertical meridian in

sutureless procedure. The induced astigmatism was less (in the range of < 1 Diopters) in sutureless procedure as compared to higher astigmatism (in the range of 1 – 2 Diopters) in conventional procedure.

Thus, larger number of patients reached astigmatically neutrality in sutureless procedures, because with-the –rule (WTR) was seen in most of the patients preoperatively. Few patients also reached astigmatically neutrality in conventional procedure also, but larger number of patients had against-the-rule (ATR) astigmatism because of larger induced astigmatism even though most patients had with-the-rule (WTR) astigmatism preoperatively.

The sub-group comparison (in small incision group) results showed that smaller incision size produces less astigmatism and less tendency to shift to against-the-rule (ATR) compared to larger incision size, which is placed superoscleraly.

In incision shape is concerned, frown incision gives less astigmatism and less tendency to shift towards the against-the-rule (ATR) compared to horizontal scratch incision.

In site is concerned, temporal site gives better control of astigmatism postoperatively compared to superoscleral incision.

Even in small incision cataract surgery, surgically induced astigmatism can be reducible as much as possible by doing incision in the steepest meridian, i.e. in WTR patients,

superoscleral frown incision is better whereas in ATR patients temporal frown incision is better.

There was an early stabilization of astigmatism in sutureless, small incision, manual phaco cataract surgery. However, the aided visual acuity in both the groups was comparable and having no significant effects.

Thus, from the above it is evident that extracapsular cataract extraction with posterior chamber lens implantation using the scleral tunnel, sutureless, selfsealing, small incision is safe and more effective (visual acuity and post operative astigmatism) method than the conventional large incision procedure, giving a good visual outcome, lesser surgically induced astigmatism and an early rehabilitation.

Conclusion

Conclusions

1. Preoperative keratometry is essential.
2. Regarding postoperative astigmatism after cataract surgery :

I.

a. Patient's age does not effect the postoperative astigmatism.

b. Involvement of the eye (right / left) does not effect the postoperative astigmatism.

c. Sex also does not effect the postoperative astigmatism.

II.

a. Larger incision ECCE i.e. conventional is ideal for all types of cataract (e.g. Brown, Black cataract..... surgery), but postoperative astigmatism is unavoidable.

III.

a. In small incision cataract surgery

1. Shorter the incision, less is the postoperative astigmatism.

2. Frown incision shape is better than straight incision for controlling postoperative astigmatism.

3. Temporal site is better than superoscleral incision for controlling surgically induced astigmatism.

4. Even in small incision cataract surgery put the incision according to the preoperative astigmatism, i.e. if it is WTR type superoscleral incision site is better. If it is ATR type, temporal incision site is better.

IV

Visual acuity concerned

1. Preoperative noting of visual acuity is essential.
2. Good visual acuity and early rehabilitation attained in small incision cataract surgery compared to conventional ECCE.

Keeping in mind the above facts it is concluded that smaller size, frown incision shape placed at temporal or superoscleral (according to preoperative astigmatism) 2 mm away from the limbus would be ideal for minimizing the postoperative astigmatism.

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Master Chart

MASTER CHART

GROUP A LARGE INCISION CATARACT SURGERY

							Preoperative					Postoperative 1st week				Postoperative 6 th week						
NO	NAME	MRD NO.	AGE	SEX	DIAG	LE/RE	V / A	K1	K2	AST	TYPE	V / A	K1	K2	AST	V / A	K1	K2	AST	TYPE	SIA*	TYPE
1	Ramshankar	17791	72	M	SMC	RE	PL+ PR +	42.00	43.25	1.25	WTR	6 / 18	43.00	46.00	3.00	6 / 9	42.00	43.00	1.00	WTR	+ 0.25	WTR
2	Ramswaroop	17207	51	M	SIMC	RE	6 / 36	43.00	44.00	1.00	WTR	6 / 12	44.00	45.00	1.00	6 / 6	44.00	44.00	0.00	N	+ 1	WTR
3	Parvati	18005	74	F	SMC	LE	FC 1 MTS	44.00	44.00	0.00	N	6 / 36	44.00	45.50	1.50	6 / 9	43.00	44.25	1.25	WTR	- 1.25	ATR
4	Shivnarayan	18486	53	M	SMC	RE	FC 1/2 MTS	46.00	46.25	0.25	WTR	6 / 24	44.00	48.00	4.00	6 / 6	44.00	46.25	1.00	WTR	- 0.75	ATR
5	Ramesh	18540	76	M	SIMC	RE	5 / 60	44.50	44.00	0.50	ATR	6 / 60	42.50	44.00	1.50	6 / 36	47.00	44.00	3.00	ATR	+ 2.5	WTR
6	Kamla	18286	56	F	SMC	LE	FC 1 MTS	41.00	42.50	1.50	WTR	6 / 60	40.00	42.00	2.00	6 / 18	42.75	40.00	2.75	ATR	+ 1.25	WTR
7	Suresh	18280	78	M	SMC	RE	PL+ PR +	42.00	43.00	1.00	WTR	6 / 9	42.00	46.00	4.00	6 / 6	43.00	43.50	0.50	WTR	+ 0.5	WTR
8	Usha Verma	19587	58	F	SMC	RE	FC 1 MTS	44.00	44.25	0.25	WTR	6 / 18	45.00	48.50	3.50	6 / 9	43.00	44.50	1.50	WTR	- 1.25	ATR
9	B.K. Jain	19394	80	M	NC	RE	FC 1 MTS	44.75	43.00	1.75	ATR	6 / 12	45.00	49.00	4.00	6 / 6	43.00	43.75	0.75	WTR	- 2.5	ATR
10	Sudha	18961	59	F	SMC	RE	FC 1/2 MTS	41.00	41.75	0.75	WTR	6 / 36	45.00	50.00	5.00	6 / 9	40.00	41.75	1.75	WTR	- 1	ATR
11	Asha	18516	61	F	SMC	RE	FC 1/2 MTS	41.00	41.75	0.75	WTR	6 / 36	43.00	49.00	6.00	6 / 6	40.00	41.25	0.25	WTR	+ 0.5	WTR
12	Ramesh Chand	19395	55	M	SMC	LE	PL+ PR +	44.75	43.00	1.75	ATR	6 / 24	41.00	44.00	3.00	6 / 12	44.00	45.50	1.50	WTR	- 3.25	ATR
13	Manko	18898	62	F	SMC	LE	FC 1/2 MTS	45.00	45.50	0.50	WTR	6 / 36	41.50	45.50	4.00	6 / 12	45.00	46.25	1.25	WTR	- 0.75	ATR
14	Ramsevak	18539	60	M	SIMC	RE	4 / 60	43.75	43.00	0.75	ATR	6 / 36	41.50	46.00	5.00	6 / 12	43.00	44.50	1.50	WTR	- 2.25	ATR
15	Ramcharan	18768	63	M	SMC	RE	FC 1/2 MTS	42.00	44.00	2.00	WTR	6 / 60	42.50	44.00	1.50	6 / 18	45.50	43.50	2.50	ATR	+ 4.5	WTR
16	Mahesh Kumar	18686	59	M	SMC	RE	FC 1/2 MTS	43.00	43.25	0.25	WTR	6 / 24	45.00	47.50	2.50	6 / 6	43.25	44.00	0.75	WTR	- 0.5	ATR
17	Raja Rani	19918	64	F	SMC	RE	PL+ PR +	43.00	43.00	0.00	N	6 / 60	46.00	48.00	2.00	6 / 18	45.75	43.00	2.75	ATR	+ 2.75	WTR
18	Shanti	20195	58	F	SMC	LE	FC 1 MTS	46.00	46.50	0.50	WTR	6 / 36	46.00	49.00	3.00	6 / 9	43.00	44.25	1.25	WTR	- 0.75	ATR
19	Premlata	20329	65	F	SMC	LE	FC 1 MTS	44.00	44.75	0.75	WTR	6 / 36	44.00	48.00	4.00	6 / 9	44.00	45.50	1.50	WTR	- 0.75	ATR
20	Raghuveer	19406	57	M	SMC	RE	FC 1 MTS	42.50	42.00	0.50	ATR	6 / 60	44.00	49.00	5.00	6 / 36	46.00	43.00	3.00	ATR	+ 2.5	WTR
21	Prabhudayal	19450	66	M	SIMC	RE	3 / 60	44.00	46.00	2.00	WTR	6 / 60	42.50	44.00	1.50	6 / 18	48.50	46.50	2.50	ATR	+ 4.5	WTR
22	Chaturbhuj	19590	56	M	SMC	RE	FC 1/2 MTS	42.00	42.75	0.75	WTR	6 / 12	44.00	46.50	2.50	6 / 9	41.00	42.75	1.75	WTR	- 1	ATR
23	Ratidevi	20457	67	F	SMC	RE	PL+ PR +	45.50	45.00	0.50	ATR	6 / 18	44.00	47.00	3.00	6 / 9	45.00	46.75	1.75	WTR	- 2	ATR
24	Heeralal	20302	55	M	SMC	RE	FC 1 MTS	45.00	45.50	0.50	WTR	6 / 36	46.00	48.00	2.00	6 / 18	47.50	45.00	2.50	WTR	- 2	ATR
25	Jawahar Singh	19393	68	M	NC	LE	FC 1 MTS	44.00	45.50	1.50	WTR	6 / 60	44.00	49.00	5.00	6 / 18	47.25	45.00	2.25	WTR	- 0.75	ATR
26	Dhanwanti	20744	54	F	SMC	RE	2 / 60	46.75	46.00	0.75	ATR	6 / 24	42.00	46.00	4.00	6 / 6	46.00	46.00	0.00	N	+ 0.75	WTR
27	Hariprasad	20201	69	M	SMC	RE	FC 1 MTS	45.00	46.25	1.25	WTR	6 / 36	40.00	46.00	6.00	6 / 9	45.00	46.25	1.25	WTR	0	N
28	Gendarani	20849	53	F	SMC	RE	PL+ PR +	42.50	42.00	0.50	ATR	6 / 60	41.50	43.00	1.50	6 / 18	44.00	42.00	2.00	ATR	+ 0.5	WTR
29	Bhawani Prasad	20925	70	M	SMC	RE	1 / 60	45.00	45.50	0.50	WTR	6 / 18	44.00	47.00	3.00	6 / 6	45.00	45.50	0.50	WTR	0	N

30	Chatur Singh	21155	52	M	SMC	LE	FC 1 MTS	43.75	42.00	1.75	ATR	6 / 12	44.00	46.50	2.50	6 / 6	43.75	44.50	0.75	WTR	- 1	ATR
31	Sunitarani	21158	64	F	SMC	RE	PL+ PR +	43.00	43.00	0.00	N	6 / 60	46.00	48.00	2.00	6 / 18	45.75	43.00	2.75	ATR	+ 2.75	WTR
32	Jameela	21245	67	F	SMC	RE	PL+ PR +	45.50	45.00	0.50	ATR	6 / 18	44.00	47.00	3.00	6 / 9	45.00	46.75	1.75	WTR	- 2.75	ATR
33	Sangeeta Gupta	21251	53	F	SMC	RE	PL+ PR +	42.50	42.00	0.50	ATR	6 / 60	41.50	43.00	1.50	6 / 18	44.00	42.00	2.00	ATR	+ 2.5	WTR
34	Ashok Kumar	21289	76	M	SIMC	RE	5 / 60	44.50	44.00	0.50	ATR	6 / 60	42.50	44.00	1.50	6 / 36	47.00	44.00	3.00	ATR	+ 2.5	WTR
35	P.C Gupta	21296	52	M	SMC	LE	FC 1 MTS	43.75	42.00	1.75	ATR	6 / 12	44.00	46.50	2.50	6 / 6	43.75	44.50	0.75	WTR	- 2.5	ATR
36	Raj kishori	21301	62	F	SMC	LE	FC 1/2 MTS	45.00	45.50	0.50	WTR	6 / 36	41.50	45.50	4.00	6 / 12	45.00	46.25	1.25	WTR	- 0.75	ATR
37	Aneesh	21406	63	M	SMC	RE	FC 1/2 MTS	42.00	44.00	2.00	WTR	6 / 60	42.50	44.00	1.50	6 / 18	45.50	43.50	2.50	ATR	- 0.5	ATR
38	Chaman Lal	21408	72	M	SMC	RE	PL+ PR +	42.00	43.25	1.25	WTR	6 / 18	43.00	46.00	3.00	6 / 9	42.00	43.00	1.00	WTR	+ 0.25	WTR
39	Waseem	21417	69	M	SMC	RE	FC 1 MTS	45.00	46.25	1.25	WTR	6 / 36	40.00	46.00	6.00	6 / 9	45.00	46.25	1.25	WTR	0	N
40	Bishan Singh	21436	70	M	SMC	RE	1 / 60	45.00	45.50	0.50	WTR	6 / 18	44.00	47.00	3.00	6 / 6	45.00	45.50	0.50	WTR	0	N
41	Manohar	21457	56	M	SMC	RE	FC 1/2 MTS	42.00	42.75	0.75	WTR	6 / 12	44.00	46.50	2.50	6 / 9	41.00	42.75	1.75	WTR	- 1	ATR
42	J Prasad	21469	55	M	NC	RE	FC 1 MTS	45.00	45.50	0.50	WTR	6 / 36	46.00	48.00	2.00	6 / 18	47.50	45.00	2.50	WTR	- 2	ATR
43	Kripaal Singh	21501	53	M	SMC	RE	FC 1/2 MTS	46.00	46.25	0.25	WTR	6 / 24	44.00	48.00	4.00	6 / 6	44.00	46.25	1.00	WTR	- 0.75	ATR
44	Usha	21508	58	F	SMC	RE	FC 1 MTS	44.00	44.25	0.25	WTR	6 / 18	45.00	48.50	3.50	6 / 9	43.00	44.50	1.50	WTR	- 1.25	ATR
45	Vineeta	22522	61	F	SMC	RE	FC 1/2 MTS	41.00	41.75	0.75	WTR	6 / 36	43.00	49.00	6.00	6 / 6	40.00	41.25	0.25	WTR	+ 0.5	WTR
46	Ramwati	22563	56	F	SMC	LE	FC 1 MTS	41.00	42.50	1.50	WTR	6 / 60	40.00	42.00	2.00	6 / 18	42.75	40.00	2.75	ATR	+ 4.25	WTR
47	Dhanwanti	22540	65	F	NC	LE	FC 1 MTS	44.00	44.75	0.75	WTR	6 / 36	44.00	48.00	4.00	6 / 9	44.00	45.50	1.50	WTR	- 0.75	ATR
48	Maya Devi	22550	74	F	SMC	LE	FC 1 MTS	44.00	44.00	0.00	N	6 / 36	44.00	45.50	1.50	6 / 9	43.00	44.25	1.25	WTR	- 1.25	ATR
49	Lalchand	21562	78	M	SMC	RE	PL+ PR +	42.00	43.00	1.00	WTR	6 / 9	42.00	46.00	4.00	6 / 6	43.00	43.50	0.50	WTR	+ 0.5	WTR
50	Sudarshan	23584	80	M	SMC	RE	FC 1 MTS	44.75	43.00	1.75	ATR	6 / 12	45.00	49.00	4.00	6 / 6	43.00	43.75	0.75	WTR	- 2.5	ATR
51	Janak Dulari	21511	59	F	SMC	RE	FC 1/2 MTS	41.00	41.75	0.75	WTR	6 / 36	45.00	50.00	5.00	6 / 9	40.00	41.75	1.75	WTR	- 1	ATR
52	Ayub Khan	21591	68	M	SMC	LE	FC 1 MTS	44.00	45.50	1.50	WTR	6 / 60	44.00	49.00	5.00	6 / 18	47.25	45.00	2.25	WTR	- 0.5	ATR
53	Chandra Grahan	22599	54	F	SMC	RE	2 / 60	46.75	46.00	0.75	ATR	6 / 24	42.00	46.00	4.00	6 / 6	46.00	46.00	0.00	N	- 0.75	ATR
54	Ashiq Ali	21609	51	M	SIMC	RE	6 / 36	43.00	44.00	1.00	WTR	6 / 12	44.00	45.00	1.00	6 / 6	44.00	44.00	0.00	N	+ 1	WTR
55	Babulal	23623	57	M	SMC	RE	FC 1 MTS	42.50	42.00	0.50	ATR	6 / 60	44.00	49.00	5.00	6 / 36	46.00	43.00	3.00	ATR	+ 2.5	WTR
56	Ajay Kumar	23689	66	M	SMC	RE	3 / 60	44.00	46.00	2.00	WTR	6 / 60	42.50	44.00	1.50	6 / 18	48.50	46.50	2.50	ATR	+ 4.5	WTR
57	Malkhan Singh	23695	59	M	SMC	RE	FC 1/2 MTS	43.00	43.25	0.25	WTR	6 / 24	45.00	47.50	2.50	6 / 6	43.25	44.00	0.75	WTR	- 0.5	ATR
58	Ghanshyam	23706	60	M	SIMC	RE	4 / 60	43.75	43.00	0.75	ATR	6 / 36	41.50	46.00	5.00	6 / 12	43.00	44.50	1.50	WTR	- 2.25	ATR
59	K.K. Kulsheshtra	23762	55	M	SMC	LE	PL+ PR +	44.75	43.00	1.75	ATR	6 / 24	41.00	44.00	3.00	6 / 12	44.00	45.50	1.50	WTR	- 3.25	ATR
60	Omi devi	21798	58	F	SMC	LE	FC 1 MTS	46.00	46.50	0.50	WTR	6 / 36	46.00	49.00	3.00	6 / 9	43.00	44.25	1.25	WTR	- 0.75	ATR

DIAG = DIAGNOSIS, LE / RE = LEFT EYE , RIGHT EYE, V/A = VISUAL ACUITY, K1,K2=PREOPERATIVE HORIZONTAL AND VERTICAL KERATOMETRY READINGS IN DIOPTERS, AST=ASTIGMATISM, PL PR = PERCEPTION OF LIGHT AND PROJECTION OF RAYS, FC = FINGER COUNTING, WTR = WITH THE RULE, ATR = AGAINST THE RULE, N=NEUTRAL, SMC = SENILE MATURE CATARACT, SIMC = SENILE IMMATURE CATARACT, NC = NUCLEAR CATARACT, SIA* = SURGICALLY INDUCED ASTIGMATISM CLACULATED FROM ALGEBRIC SUBSTRACTION METHOD IN DIOPTERS.

MASTER CHART

GROUP B SMALL INCISION (MANUAL) CATARACT SURGERY

							Preoperative						Postoperative 1 st week					Postoperative 6 th week						
NO	NAME	MRD NO.	AGE	SEX	DIAG	LE/RE	V / A	K1	K2	AST	TYPE	TOP	V / A	K1	K2	AST	TYPE	V / A	K1	K2	AST	TYPE	SIA*	TYPE
	Incision Size 6.5 mm, shape horizontal, site superoscleral																							
1	Benibai	2532	52	F	SMC	R E	PL+, PR +	44.00	44.50	0.50	W	SH 6.5 MM	6 / 36	44.00	46.00	2.00	WTR	6 / 6	44.00	45.00	1.00	WTR	- 0.5	ATR
2	Haribaba Agarwal	2534	55	M	SIMC	R E	< 6 / 36	46.00	46.50	0.50	W	SH 6.5 MM	6 / 12	46.50	47.00	0.50	WTR	6 / 6	46.50	46.50	0.00	N	+ 0.5	WTR
3	Ashok Kumar	2540	58	M	NC	L E	FC 1 MTS	47.00	47.75	0.75	W	SH 6.5 MM	6 / 24	47.00	48.25	1.25	WTR	6 / 9	47.00	47.12	0.12	ATR	+ 0.9	WTR
4	Pradeep Jain	2911	53	M	SMC	R E	FC 1/2 MT	45.00	45.50	0.50	W	SH 6.5 MM	6 / 36	45.00	46.75	1.75	WTR	6 / 9	45.00	45.00	0.00	N	+ 0.5	WTR
5	Ramdulari	3404	61	F	SMC	L E	< 4 / 16	44.00	44.25	0.25	W	SH 6.5 MM	6 / 12	44.25	45.00	0.75	WTR	6 / 6	44.00	44.00	0.00	N	+ 0.3	WTR
6	Chandrapal Singh	3069	57	M	NC	R E	FC 1 MTS	42.00	42.75	0.75	W	SH 6.5 MM	6 / 18	42.00	43.75	1.75	WTR	6 / 6	42.00	42.75	0.75	WTR	0	N
7	Baboo Khan	3281	60	M	SMC	L E	FC 1 MTS	44.00	44.50	0.50	W	SH 6.5 MM	6 / 60	44.00	46.25	2.25	WTR	6 / 36	44.00	45.50	1.50	WTR	- 1	ATR
8	Balkishan	3248	64	M	SMC	L E	PL+, PR +	42.00	42.75	0.75	W	SH 6.5 MM	6 / 36	44.00	46.00	2.00	WTR	6 / 9	44.50	44.00	0.50	ATR	+ 1.3	WTR
9	Ramprasad	3418	56	M	PSC	L E	FC 1 MTS	45.00	45.50	0.50	W	SH 6.5 MM	6 / 24	44.00	45.50	1.50	WTR	6 / 9	44.00	44.75	0.75	WTR	- 0.5	ATR
10	Subdhra	4346	66	F	SIMC	L E	< 5 / 16	43.00	43.50	0.50	W	SH 6.5 MM	6 / 12	43.00	43.00	0.00	N	6 / 9	43.50	43.00	0.50	ATR	+ 1	WTR
11	Rekha Yadav	4357	66	F	SIMC	L E	< 5 / 16	43.00	43.50	0.50	W	SH 6.5 MM	6 / 12	43.00	43.00	0.00	N	6 / 9	43.50	43.00	0.50	ATR	+ 1	WTR
12	Shankar Nagpal	2544	55	M	SIMC	R E	< 6 / 36	46.00	46.50	0.50	W	SH 6.5 MM	6 / 12	46.50	47.00	0.50	WTR	6 / 6	46.50	46.50	0.00	N	+ 0.5	WTR
13	Begam khatoon	2542	52	F	SMC	R E	PL+, PR +	44.00	44.50	0.50	W	SH 6.5 MM	6 / 36	44.00	46.00	2.00	WTR	6 / 6	44.00	45.00	1.00	WTR	- 0.5	ATR
14	Ashok Batra	3579	57	M	NC	R E	FC 1 MTS	42.00	42.75	0.75	W	SH 6.5 MM	6 / 18	42.00	43.75	1.75	WTR	6 / 6	42.00	42.75	0.75	WTR	0	N
15	Kalicharan Das	3424	56	M	PSC	L E	FC 1 MTS	45.00	45.50	0.50	W	SH 6.5 MM	6 / 24	44.00	45.50	1.50	WTR	6 / 9	44.00	44.75	0.75	WTR	- 0.3	ATR
16	Puneet Jain	2921	53	M	SMC	R E	FC 1/2 MT	45.00	45.50	0.50	W	SH 6.5 MM	6 / 36	45.00	46.75	1.75	WTR	6 / 9	45.00	45.00	0.00	N	+ 0.5	WTR
17	Vandana	3414	61	F	SMC	L E	< 4 / 16	44.00	44.25	0.25	W	SH 6.5 MM	6 / 12	44.25	45.00	0.75	WTR	6 / 6	44.00	44.00	0.00	N	+ 0.3	WTR
18	Jagdish	2550	58	M	NC	L E	FC 1 MTS	47.00	47.75	0.75	W	SH 6.5 MM	6 / 24	47.00	48.25	1.25	WTR	6 / 9	47.00	47.12	0.12	ATR	+ 0.9	WTR
19	Irshad Khan	3291	60	M	SMC	L E	FC 1 MTS	44.00	44.50	0.50	W	SH 6.5 MM	6 / 60	44.00	46.25	2.25	WTR	6 / 36	44.00	45.50	1.50	WTR	- 1	ATR
20	Bhagat Lal	3258	64	M	SMC	L E	PL+, PR +	42.00	42.75	0.75	W	SH 6.5 MM	6 / 36	44.00	46.00	2.00	WTR	6 / 9	44.50	44.00	0.50	ATR	+ 1.3	WTR
	Incision Size 8 mm, shape horizontal, site superoscleral																							
21	Ghanshyam	2531	54	M	NC	L E	FC 1 MTS	46.50	45.00	1.50	A	SH 8 MM	6 / 24	45.00	47.00	2.00	WTR	6 / 6	45.00	46.50	1.50	WTR	- 3	ATR
22	Jayshree	2522	69	F	SMC	R E	PL+, PR +	45.50	45.25	0.25	A	SH 8 MM	6 / 9	45.00	44.75	0.25	ATR	6 / 6	45.00	45.00	0.00	N	- 0.3	ATR
23	Jagdish	2910	58	M	SMC	L E	FC 1 MTS	43.75	43.00	0.75	A	SH 8 MM	6 / 18	44.00	43.00	1.00	ATR	6 / 9	43.50	43.00	0.50	ATR	- 0.3	ATR
24	Ramprasad	2681	59	M	PSC	R E	FC 1 MTS	46.50	46.00	0.50	A	SH 8 MM	6 / 18	48.00	46.00	2.00	ATR	6 / 12	47.50	46.00	1.50	ATR	+ 0.5	WTR
25	Gomti	3457	70	F	SMC	R E	< 4 / 16	43.00	43.00	0.00	N	SH 8 MM	6 / 12	43.00	43.75	0.75	WTR	6 / 12	43.00	43.50	0.50	WTR	- 0.5	ATR
26	Sheela	3226	55	F	SMC	L E	FC 1/2 MT	45.00	46.00	1.00	W	SH 8 MM	6 / 9	45.00	46.50	1.50	WTR	6 / 6	45.00	45.00	0.00	N	+ 1	WTR
27	Brijmohan	3403	59	M	SMC	L E	PL+, PR +	47.00	45.00	2.00	A	SH 8 MM	6 / 24	47.00	45.00	2.00	ATR	6 / 18	46.50	45.00	1.50	ATR	- 0.5	ATR
28	Prakash	3948	63	M	PSC	R E	FC 1/2 MT	44.00	44.00	0.00	N	SH 8 MM	6 / 12	45.00	44.00	1.00	ATR	6 / 9	45.50	44.00	0.50	ATR	- 0.5	ATR
29	Geeta	4729	52	F	SMC	R E	FC 1/2 MT	46.00	44.00	2.00	A	SH 8 MM	6 / 12	46.75	46.00	0.75	ATR	6 / 9	46.75	46.00	0.75	ATR	+ 2.8	WTR
30	Ramsevak	4355	72	M	NC	R E	PL+, PR +	44.00	44.50	0.50	W	SH 8 MM	6 / 12	44.00	44.50	0.50	WTR	6 / 9	44.00	44.50	0.50	WTR	0	N

	Incision Size 6.5 mm, shape frown, site superoscleral																									
31	B.R. Sharma	4317	51	M	SMC	L E	FC 1 MTS	44.00	45.00	1.00	W	SF 6.5 MM	6 / 18	44.00	45.00	1.00	WTR	6 / 9	44.00	44.25	0.25	WTR	+	0.8	WTI
32	Rajkumari	4547	75	F	SIMC	R E	< 3 / 16	42.00	44.00	2.00	W	SF 6.5 MM	6 / 36	43.00	44.75	1.75	WTR	6 / 12	43.00	45.00	2.00	WTR		0	N
33	Baboo lal	4893	59	M	SMC	R E	FC 1 MTS	42.00	44.00	2.00	W	SF 6.5 MM	6 / 24	42.00	43.50	1.50	WTR	6 / 9	42.00	42.00	0.00	N	+	2	WTI
34	Devi Prasad	5032	67	M	NC	L E	PL+, PR +	45.00	46.50	1.50	W	SF 6.5 MM	6 / 36	44.50	47.00	2.50	WTR	6 / 12	45.00	46.00	0.50	WTR	+	1	WTI
35	Asha	6659	58	F	PSC	R E	FC 1 MTS	44.00	45.75	1.75	W	SF 6.5 MM	6 / 24	44.00	45.50	1.50	WTR	6 / 9	44.00	44.00	0.00	N	+	1.8	WTI
36	Naseer	7577	62	M	SMC	L E	FC 1 MTS	42.00	43.25	1.25	W	SF 6.5 MM	6 / 12	44.50	45.00	0.50	WTR	6 / 6	44.50	44.50	0.00	N	-	1.3	ATF
37	Paras	7534	54	M	SMC	R E	< 3 / 16	45.00	46.50	1.50	W	SF 6.5 MM	6 / 24	45.00	46.75	1.50	WTR	6 / 9	45.00	45.75	0.75	WTR	+	0.8	WTI
38	Balkishan	6700	68	M	NC	R E	FC 1/2 MT	45.00	46.75	1.75	W	SF 6.5 MM	6 / 24	45.00	46.75	1.75	WTR	6 / 9	45.00	45.50	0.50	WTR	+	1.3	WTI
39	Radhadevi	4339	52	F	SMC	L E	PL+, PR +	46.00	46.00	0.00	N	BF 6.5 MM	6 / 9	46.00	44.50	0.50	WTR	6 / 6	46.00	46.00	0.00	N		0	N
40	G.P. Mishra	4386	57	M	SMC	R E	FC 1/2 MT	44.00	44.00	0.00	N	BF 6.5 MM	6 / 9	44.00	44.50	0.50	WTR	6 / 6	44.00	44.00	0.00	N		0	N
41	Sitadevi	4349	52	F	SMC	L E	PL+, PR +	46.00	46.00	0.00	N	BF 6.5 MM	6 / 9	46.00	44.50	0.50	WTR	6 / 6	46.00	46.00	0.00	N		0	N
42	Pratap Singh	7544	54	M	SMC	R E	< 3 / 16	45.00	46.50	1.50	W	SF 6.5 MM	6 / 24	45.00	46.75	1.50	WTR	6 / 9	45.00	45.75	0.75	WTR	+	0.8	WTI
43	Omkar Nath	4894	59	M	SMC	R E	FC 1 MTS	42.00	44.00	2.00	W	SF 6.5 MM	6 / 24	42.00	43.50	1.50	WTR	6 / 9	42.00	42.00	0.00	N	+	2	WT
44	Beni Prasad	5132	67	M	NC	L E	PL+, PR +	45.00	46.50	1.50	W	SF 6.5 MM	6 / 36	44.50	47.00	2.50	WTR	6 / 12	45.00	46.00	0.50	WTR	+	1	WT
45	Babulal Rai	4327	51	M	SMC	L E	FC 1 MTS	44.00	45.00	1.00	W	SF 6.5 MM	6 / 18	44.00	45.00	1.00	WTR	6 / 9	44.00	44.25	0.25	WTR	+	0.8	WT
46	Nandpal	7578	62	M	SMC	L E	FC 1 MTS	42.00	43.25	1.25	W	SF 6.5 MM	6 / 12	44.50	45.00	0.50	WTR	6 / 6	44.50	44.50	0.00	N	+	1.3	WT
47	Sunita Singh	6660	58	F	PSC	R E	FC 1 MTS	44.00	45.75	1.75	W	SF 6.5 MM	6 / 24	44.00	45.50	1.50	WTR	6 / 9	44.00	44.00	0.00	N	+	1.8	WT
48	Ballu Chouhan	6788	68	M	NC	R E	FC 1/2 MT	45.00	46.75	1.75	W	SF 6.5 MM	6 / 24	45.00	46.75	1.75	WTR	6 / 9	45.00	45.50	0.50	WTR	+	1.3	WT
49	Ramdulari	4548	75	F	SIMC	R E	< 3 / 16	42.00	44.00	2.00	W	SF 6.5 MM	6 / 36	43.00	44.75	1.75	WTR	6 / 12	43.00	45.00	2.00	WTR		0	N
50	Udaybhan Singh	4376	57	M	SMC	R E	FC 1/2 MT	44.00	44.00	0.00	N	BF 6.5 MM	6 / 9	44.00	44.50	0.50	WTR	6 / 6	44.00	44.00	0.00	N		0	N
	Incision Size 6.5 mm, shape frown, site temporal																									
51	Phool Chand	4344	54	M	NC	L E	FC 1 MTS	46.50	45.00	1.50	A	TF 6.5 MM	6 / 24	46.50	45.00	1.50	ATR	6 / 9	45.12	45.00	0.12	ATR	-	1.3	ATF
52	Sundrebai	4501	69	F	SMC	R E	PL+, PR +	45.50	45.25	0.25	A	TF 6.5 MM	6 / 9	45.00	44.75	0.25	ATR	6 / 6	45.00	45.00	0.00	N	-	0.3	ATF
53	Raghuveer	5045	58	M	SMC	L E	FC 1 MTS	43.75	43.00	0.75	A	TF 6.5 MM	6 / 18	44.50	43.00	1.50	ATR	6 / 6	43.12	43.00	0.12	ATR	-	0.7	ATF
54	V.V. Saxena	5041	59	M	PSC	R E	FC 1 MTS	46.50	46.00	0.50	A	TF 6.5 MM	6 / 18	47.00	46.00	1.00	ATR	6 / 6	46.25	46.00	0.25	ATR	-	0.3	ATF
55	Premlata	7316	70	F	SMC	R E	< 4 / 16	45.50	45.00	0.50	A	TF 6.5 MM	6 / 12	46.25	45.00	1.25	ATR	6 / 6	45.50	45.00	0.50	ATR		0	N
56	Mumtaz	6016	55	F	SMC	L E	FC 1/2 MT	45.00	43.00	2.00	A	TF 6.5 MM	6 / 24	45.25	44.00	1.25	ATR	6 / 6	44.12	44.00	0.12	ATR	-	1.8	ATF
57	M.K. Agarwal	7522	59	M	SMC	L E	PL+, PR +	40.50	40.00	0.50	A	TF 6.5 MM	6 / 18	46.50	45.00	1.50	ATR	6 / 6	45.00	45.25	0.25	ATR	+	0.3	WT
58	Chintaram	7797	63	M	PSC	R E	FC 1/2 MT	46.00	44.00	2.00	A	TF 6.5 MM	6 / 9	45.00	44.00	1.00	ATR	6 / 6	44.00	44.00	0.00	N	-	2	ATF
59	Laxmi	7801	52	F	SMC	R E	FC 1/2 MT	47.25	45.00	2.25	A	TF 6.5 MM	6 / 9	46.00	45.00	1.00	ATR	6 / 6	45.00	45.00	0.00	N	-	2.3	ATF
60	Ghamdilal	7805	72	M	NC	R E	PL+, PR +	44.00	44.50	0.50	W	SH 8 MM	6 / 12	44.00	44.50	0.50	WTR	6 / 9	44.00	44.50	0.50	WTR		0	N

DIAG = DIAGNOSIS, LE / RE = LEFT EYE , RIGHT EYE, V/A = VISUAL ACUITY, K1,K2=PREOPERATIVE HORIZONTAL AND VERTICAL KERATOMETRY READINGS, AST=ASTIGMATISM, PL PR = PERCEPTION OF LIGHT AND PROJECTION OF RAYS, FC = FINGER COUNTING, WTR = WITH THE RULE, ATR = AGAINST THE RULE, N=NEUTRAL, SMC = SENILE MATURE CATARACT, SIMC = SENILE IMMATURE CATARACT, NC = NUCLEAR CATARACT, SIA* = SURGICALLY INDUCED ASTIGMATISM CLACULATED FROM ALGEBRIC SUBSTRACTION METHOD., SH = SUPEROSCLERAL HORIZONTAL INCISION, SF = SUPEROSCLERAL FROWN INCISION, BF = BENT FROWN INCISION, TF = TEMPORAL FROWN INCISION.